GUAM AGRICULTURAL EXPERIMENT STATION,
C. W. EDWARDS, Animal Husbandman in Charge.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE GUAM AGRICULTURAL EXPERIMENT STATION.

1918.

Issued October 14, 1919.

WASHINGTON:
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GUAM AGRICULTURAL EXPERIMENT STATION, ISLAND OF GUAM.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*
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LETTER OF TRANSMITTAL.

GUAM AGRICULTURAL EXPERIMENT STATION,
Island of Guam, November 30, 1918.

SIR: I have the honor to transmit herewith a report of the Guam Agricultural Experiment Station, 1918.

Very respectfully,

C. W. EDWARDS,
Animal Husbandman in Charge.

DR. A. C. TRUE,
Director States Relations Service.
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON, *Secretary of Agriculture.*

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By C. W. Edwards.

INTRODUCTION.

The work of the station for the past fiscal year has been conducted along the same general lines as in the previous year. On the whole the results were satisfactory, especially when certain adverse conditions are considered, the lack of transportation facilities having made it difficult to obtain supplies at times when most needed and the greatly increased cost of materials and supplies having interfered with the progress of work. The agronomic work was also hampered by the presence at certain seasons of various insect pests, by the lack of sufficient work animals, and by the fact that most of the work was conducted on newly broken grassland, which, it has been found, will not produce well until after it has been broken up and cultivated for some time.

The island government gave considerable assistance in the work of the year, principally by furnishing labor. The government also leased during the early part of the fiscal period, for the use of the station, a tract of land comprising approximately 30 acres and adjoining the Piti station property on the west.[1] The use of this property provides the station with ample area for conducting the various lines of experimental work on a sufficiently extensive scale, and also for producing forage for live stock.

Special effort has been devoted to increased food production. The work has been carried on mainly in cooperation with the insular patrolmen (U. S. marines) stationed in the various districts and with teachers, municipal commissioners, and representative farmers. Increased quantities of seed and plant material have been distributed and better methods of cultivation have been urged, especially the more general use of animal-drawn machines in place of the fosiño and machete. Emphasis has been placed on the growing of such crops as taro, corn, beans, bananas, and sweet potatoes.

[1] The lease covers a period of only 5 years, as it was impossible to arrange for a longer period through the local administrator. Efforts are being made to secure an extension of the lease period to 25 years.

The chief lines of agronomic and horticultural experimental work being conducted are those dealing with the production of corn, rice, coconuts, vegetables, forage, cover and green manure crops. The growing of green manures is of special importance in Guam and many other tropical countries, where the housing of animals is not practiced and consequently stable manure is not available for fertilizer purposes.

In animal husbandry considerable attention is being given to the production of feeds, along with the effort to establish station breeding herds and flocks and to upgrade the privately-owned native stock. The determination of suitable local feeds as substitutes for imported ones is of prime importance to stock raisers in Guam and other tropical places whose isolation makes the importation of feeds impracticable. Comparatively little trouble was experienced during the year from diseases or pests. Few deaths occurred, although the losses among the cattle and swine included the pure-blood stud sires. The death of pure-blood servicable breeding animals always constitutes a serious loss because of the great difficulty encountered in the importation of live stock from the mainland. However, the work has been developed to such an extent that some progress can be made by using the station grade sires. The major portion of the station horses was transferred to the island government during the month of September. As explained later, it was considered advisable to discontinue the horse-breeding work with the exception of that phase pertaining to the upgrading of the native ponies of the island.

A complete set of instruments was received from the Weather Bureau of the United States Department of Agriculture and installed during the latter part of the last fiscal year. The taking of observations was begun on July 1, 1917.

The second Guam Industrial Fair was opened in Agana on July 3, 1918. A creditable display of agricultural products and live stock was presented by the farmers of the various districts. The station's exhibit (Pl. I) emphasized the importance of seed selection in connection with the work of increased food production. It was planned to continue the fair until the morning of July 7, but the event was suddenly terminated by the typhoon which swept the island on July 6.

W. H. Weston, jr., a plant pathologist of the United States Department of Agriculture, spent the month of March studying plant disease conditions in Guam. Doctor Weston is to be commended for the amount of work accomplished during so short a stay on the island. His report [1] emphasizes the need of an entomologist-pathologist on the station staff. There is also urgent need for an extension worker. The

[1] Guam Sta. Rpt. 1917, pp. 45–62.

station duties make it impossible for the present staff to spend more than a very limited time in the field, and the disposition of the Chamorro farmer is such that in order to properly conduct cooperative demonstration work continuous supervision is necessary. To provide for this increase in the staff and for the proper development of the various lines of station work more funds are needed.

The construction of a seed and general laboratory building, a forage building, and residences for station laborers and staff; the installation of a sewer system; the erection of new fences; and the repair of roads constitute some of the more important station improvements needed at present.

ANIMAL HUSBANDRY.

HORSES.

The work with horses, with the exception of that pertaining to the upgrading of the native stock of the island, was discontinued with the transfer on September 27 of a major portion of the stud to the naval government of Guam. The stallion Donald (Pl. II, fig. 1), the yearling colt William Cassius, and the mare Mayport were retained by the station. The stallion is to be used for public service in connection with the work of improving the local native stock, the mare Mayport will be kept for saddle and work purposes, while William Cassius will be used later for mating with the grade offspring sired by Donald.

The original pure-blood Morgan introduction, comprising four fillies, one young stallion, and one yearling male colt, arrived on the island October 12, 1911. The object of this importation was to test the adaptability of these pure-blood Morgans and their locally grown progeny to tropical conditions, to use the sires in the work of upgrading the inferior native ponies of the island, also to use the stock for station work purposes as much as practicable. Although the number of animals comprising the station stud at any one time was insufficient to admit of the drawing of definite conclusions in connection with most phases of the work, considerable data of interest have been collected. A brief summary of these data, a large portion of the substance of which has appeared from time to time in previous reports of this station, is given herewith.

The total of results obtained tend to indicate that the Morgan is comparatively well adapted to tropical conditions. While in the possession of the station the horses in question were never worked for long-continued periods. Most of them were used for transportation and light work purposes at various intervals, while the others were used for breeding purposes only. Of the number transferred to the naval government, the mature individuals were apparently able

within a short period to endure continuous and relatively hard work. As would naturally be expected, the imported horses required a great deal more care and attention and considerably more feed to maintain them in good condition during the 18 months or so following their arrival than they did thereafter, while their pure-blood Guam-grown progeny proved, with the exception of one individual, to be much better adapted to local conditions than did their imported parents. During the acclimatization period much extra attention was required because of the difficulty experienced in the healing of skin wounds. The great prevalence of tetanus on the island causes open wounds to be a constant source of danger. During the dry season the feet required special treatment to prevent drying and cracking of the frog and wall of the hoof. On the whole, the general health of the stud during the entire period was very good. With the exception of a short period of illness of one stallion, due to an attack of pneumonia, and the death of one foal from tetanus, there was an absence of serious cases of illness or contagious and infectious diseases.

With respect to breeding habits the imported horses showed a greater degree of variability than is generally the case with horses in temperate climates. This was especially true during the first few years following their importation. In the case of all mares the œstrum was very irregular, and in most cases of those producing foals the condition continued at various intervals throughout the period of pregnancy. There was also a tendency toward barrenness at various times in all the mares. From observations and work with a large number of imported American and Australian mares in the Philippine Islands, these irregularities in breeding habits are thought to be of very common occurrence. There seems to be no doubt that at certain periods the sires were sterile, this being especially true in the case of Cassius. Of the total number of mares bred to the latter only 27.66 per cent became pregnant, while of those bred to Donald 44.12 per cent conceived. The low percentage of conception in each case was due in part to the fact that a number of mares served were old, especially some of the imported animals. Of this class of mares mated with the two sires, however, the greater number were bred to Donald. The records show that of the two stallions the latter possessed much the greater begetting powers.

In the work of upgrading the native stock, only a comparatively small number of native mares have been bred to the station stallions. This is due to a number of causes. At first the native farmer feared that the small mares would be injured in service with the larger stallion or would be unable to deliver the grade foals, which fears experience proved to be groundless. At the time of the inception of the work, native ponies were in great demand, principally for public

AGRONOMY AND HORTICULTURAL EXHIBITS AT GUAM INDUSTRIAL FAIR, JULY, 1918.

Sign in background composed wholly of Guam-grown seeds.

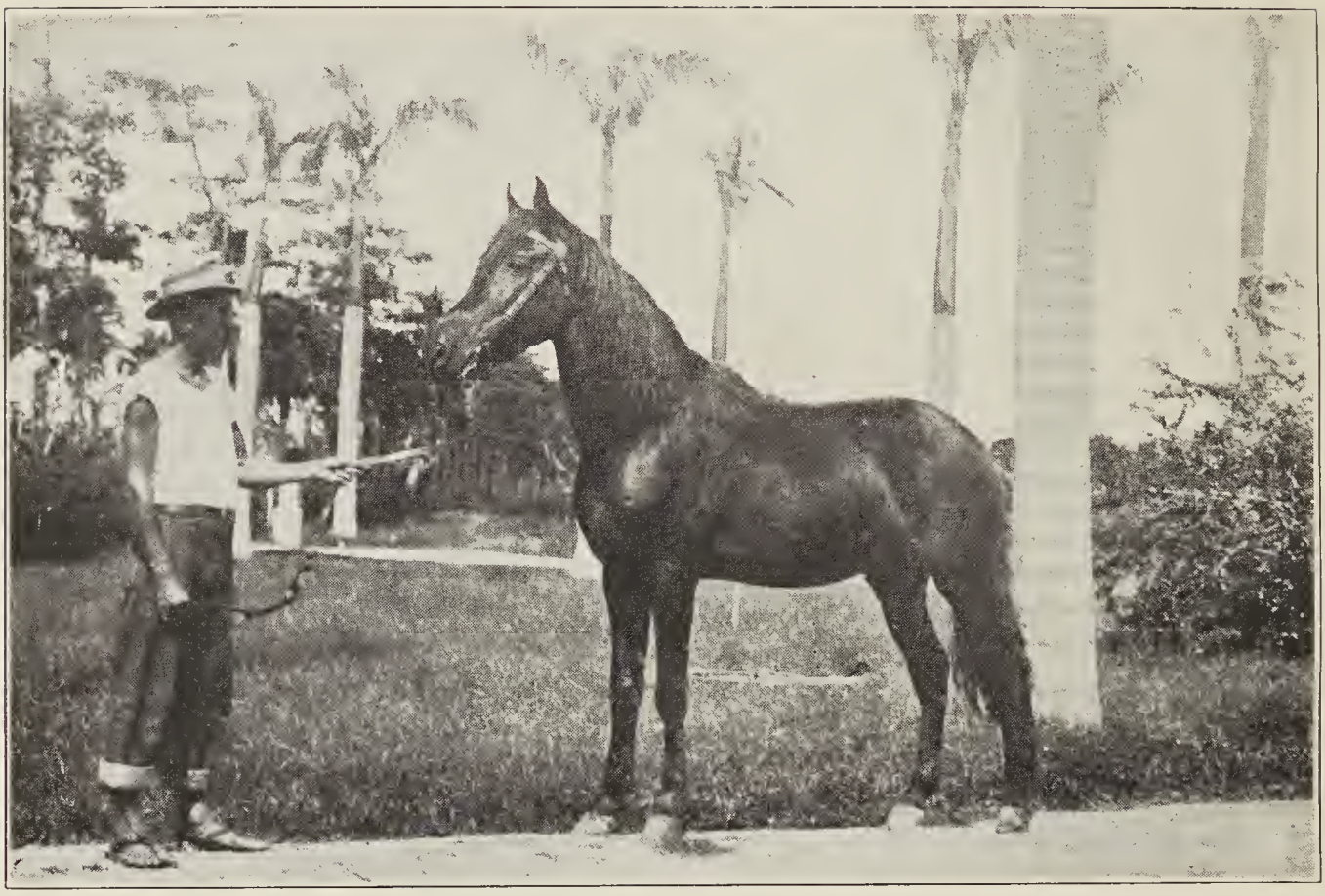

FIG. 1.—MORGAN STALLION DONALD.

FIG. 2.—NATIVE MARE AND HALF-BLOOD MORGAN PROGENY.

Left, dam, weight 460 pounds; center, mature gelding, weight 665 pounds.

transportation purposes. A short time later they were displaced by the automobile, and a majority of these ponies were then turned on ranges in remote and difficultly accessible localities where little or no attention was given them. There are also a number of difficulties encountered in hand-breeding native mares which for the best results necessitates that they be close at hand where they can be under continual observation. A plan has been formulated whereby the native mares will be brought in for service and left at the station until it is reasonably sure that they are in foal. Prior to the transfer of the station horses stable and forage facilities did not admit of such procedure. Loaning out the station sires was found to be entirely inadvisable.

The native ponies of the island are of Philippine introduction. A majority of them are small, averaging approximately 450 pounds, and are otherwise very poor type individuals, although they possess extreme hardiness and show remarkable endurance and strength for their size.

Only grade offspring of the first generation have been produced so far in the work of upgrading or improving this native stock. Of the small number raised each individual shows a very marked improvement in size and conformation over the pure native pony, is apparently able to subsist on the native pasture alone, and is otherwise equal in hardiness to the native parent. (Pl. II, fig. 2.) It is anticipated, however, that continuation of the work for a sufficiently long time to produce a satisfactory type of horse will necessitate in conjunction with the breeding work the use of better feed and the employment of improved methods of care and handling. The average weight of the mature grades is approximately 700 pounds. Records are being kept of the weights, body measurements, and other characteristics of the native dams and their grade offspring.

No difficulty was experienced by the station in producing crops suitable for the roughage portion of the ration of the Morgan horses. Para as soiling grass and *Paspalum dilatatum* as pasture were the principal and most satisfactory crops utilized for this purpose. Sorghums were also successfully fed as green forage for various periods of considerable duration, and Sudan grass, velvet-bean vines, and wild morning-glory vines were also fed green for short periods with no ill effects.

In a test comparing the feeding values of Para grass and alfalfa hay, in conjunction with a grain ration of oats, the alfalfa proved the more efficient, especially for increasing the weight of horses in poor condition. Para grass proved a satisfactory roughage for animals in normal condition when used at light work. A ration of

1 part alfalfa hay and 8 parts, by weight, of Para grass also constituted a satisfactory roughage combination.

In connection with observations relative to miscellaneous forage plants and grasses, it was noted that aroma (*Acacia farnesiana*), which grows in abundance throughout the island, proves very troublesome in horse pastures. Contact with the thorns of this shrub causes swellings, usually about the lips, nose, and other parts of the head and on the legs, these swellings often developing into raw sores. *Andropogon aciculatus*, one of the most common pasture grasses of the island, is noxious because of the adherent awn which very often causes conjunctivitis and sores about the face and head. The leaves of the shrub *Leucæna glauca*, commonly found growing in pastures, when fed upon continuously by horses often cause the hair of the mane and tail to fall.

It was found impossible to maintain pure-blood Morgans on native or introduced grass pastures or on green soiling crops such as Para without the addition of a grain ration. The bulk of the grain fed has to be imported. There is little doubt but that suitable rations could be formed from the grain crops which can be produced locally. With the exception of corn, however, these are not produced by the island farmers to any considerable extent, and corn in quantity is only available at certain seasons and even then generally at prices in excess of the imported product. The amount of grain accruing from the experimental work conducted by the station was never sufficient to maintain the station horses. Under these conditions the total cost of maintenance of a mature Morgan horse was estimated at approximately $140 per year.

In a three months' feeding test with 6 Morgan horses a grain ration composed of equal parts by weight of copra meal and oats gave as good results as an entire oat ration. One-half the weight of the regular oat ration of 4 horses was also substituted with native corn for a number of months without any loss of weight or other ill effects in the animals.

Owing to the disposition of the native farmer and the nature of his conditions it does not appear that horses could be satisfactorily substituted for cattle and carabao for farm work purposes. The average native knows little of the proper handling of horses. Cattle and carabao in his hands are naturally much more tractable. They require less care and also less expense to maintain than would horses of sufficient size to perform most farm operations. The development of a larger type work bullock is considered of far more importance in the agricultural development of the island than the production of horses.

Because most of the station work necessitates a great deal of hand labor and the Morgans are too light for heavy farm operations and

too spirited to be handled by the average native laborer, the horses of the stud were never used to any extent for station work purposes.

Mainly for the reasons set forth and the fact that the small amount of funds available did not admit of an extension of the scope of the work, which would be necessary in order to obtain a considerable amount of conclusive data, it was deemed that the conditions and circumstances did not justify a continuation of the project except that part dealing with the improvement of the native pony. It is believed that the native rancher could use an improved type of pony to very good advantage for saddle, driving, and pack purposes and for light field work. For this reason it is considered that the public breeding work or upgrading of native stock is of sufficient importance to warrant the small expenditure necessary for the continuation of this phase of the project.

CATTLE.

HISTORY OF THE WORK.

The cattle of the island, probably of Mexican origin with later introductions from the Philippine Islands, are small and of poor conformation, but are extremely hardy and possess very good rustling qualities. Cattle are of prime importance to the native rancher, who uses them for draft, driving, saddle, beef, and, to a very small extent, milk purposes, although no effort has been made by the people toward the development of types especially adapted for these various uses. The climatic, market, and other conditions are such that cattle raising should be one of the most important industries of the island. Aside from the remote possibility that the raising of purely foreign or imported cattle may become a general practice, a production of beef and dairy products sufficient to meet to any great extent the present local demand would necessitate a great improvement in the size, conformation, and beef and milking qualities of the native stock. In order to bring this about, upgrading, or the infusion of foreign blood, selection, improvement of pastures, production of additional suitable feeds, and control of cattle ticks must be practiced.

The initial upgrading work is being undertaken by the station through the use of Ayrshire blood, the feasibility of pasture improvement by the use of Para and Paspalum grasses is being demonstrated, and cattle owners are being induced to practice general methods of selection. Aside from a few Jersey cows brought in some years ago for milk purposes by the Navy Department and by the American missionaries, the Ayrshires so far as known are the only pure-bred or improved cattle which have been introduced. As

yet only one small importation of Ayrshires has been made, a shipment consisting of one 2-year-old bull, one male calf, and two cows having been received by this station on October 12, 1911. The object of this importation, aside from upgrading purposes, was to test the adaptability of pure-bred Ayrshires to local conditions.

Effect of cattle ticks on imported and locally grown Ayrshires.—A record of the experience with these cattle is of value as showing the effect of the locally prevalent cattle tick upon animals introduced from nontick-infested districts. Both *Margaropus annulatus australis* and *M. annulatus* have been described as being present on the island. Although the presence in the blood of the native cattle of the Texas fever organism *Piroplasma bigeminum* has never been definitely identified, the Ayrshire cattle which were introduced from the State of Washington for some years following their introduction showed symptoms very similar to those of Texas fever whenever they became tick-infested. Of the original importation, one bull and one cow died from this so-called tick disease. The two remaining, one cow and one bull, have apparently acquired complete immunity to the disease. Several years elapsed, however, before this condition obtained. With one possible exception the Guam-grown pure-blood progeny of the imported stock have been entirely immune to the malady.

Maintenance requirements.—A study of the records of the few head of imported and locally produced Ayrshires presents some interesting data as to adaptibility as shown by maintenance requirements. The imported animals for the first few years following their introduction required a fairly heavy grain ration in addition to improved green forage. This observation is based upon the records of the animals for periods exclusive of those during which they showed ill effects from the presence of ticks. Of the two imported animals previously mentioned as being still on hand, the bull requires in addition to green forage only a small daily grain allowance for the maintenance of proper condition, while the cow is kept in good flesh on cut Para and Paspalum pasture alone. The experience with the Guam-raised pure-bloods indicates that they can be maintained entirely on the improved green forage.

Shade.—Some of the animals of the pure-blood herd for a considerable time after their introduction were affected by the heat of the sun to such an extent that it was found necessary on clear days to keep them stabled during the heat of the day. This was principally true of the two head still on hand. At the present time neither one of these animals seems to be affected by this cause to a greater extent than the average native animal.

Dairy qualities.—In regard to the milking qualities of the imported and locally raised Ayrshires, the records of the two imported cows,

taken during the second year following their introduction, show a low yield, which, however, may have been due principally to the effect of the ticks and the general results of acclimation. The yields of two Guam-raised pure-bloods, although surpassing those of the imported cows, do not equal the yield of the average pure-blood animal of the same breed in the States.

The tendency of dairy cattle imported into the Tropics from a temperate climate to show a decrease in milk production, even after they have apparently become thoroughly acclimated, was noted by the writer in the case of a comparatively large number of dairy cattle in the Philippine Islands. A determination of the influences causing this decrease in production and securing of data as to the dairy qualities of the successive generations of locally grown progeny of the imported cattle and the degree to which the pure-blood or improved animals can transmit their milking qualities to their offspring when crossed with the native stock are lines of work of the utmost importance to the tropical dairyman.

Upbreeding work.—As previously mentioned, one of the principal objects of the Ayrshire importation was to utilize the stock in the upbreeding or improvement of the native cattle, the work to be accomplished by keeping bulls at the station for free public service and by the production and distribution of grade bulls for breeding purposes.

Previous to the fiscal year 1914 the work directed toward this end was confined to the breeding of the privately-owned native cows brought to the Piti station for service to the two imported bulls and the production of a few grade calves from the small number of station native cows kept at Piti. During the year additional native cows were purchased, and near the close of the period a tract of pasture land was purchased, subsequently known as the Cotot stock farm, to which 15 of these cows were transferred in December to become the foundation herd in the grade production work.

By the close of the fiscal year 1918, or during a period of four years, the increase from this original herd (of calves of weaning age) has numbered 23 head, 15 females and 8 males, or an increase of 38.33 per cent. Owing to the periodic illness of the bull Harry Gray, as mentioned in previous reports, the herd was without a sire at various intervals, some of these periods being of considerable duration. For this reason the percentage of get is somewhat lower than it would ordinarily have been. Notwithstanding this fact, however, it is believed that this is a higher rate of increase than that of most native herds on the island.

In the grade production work only a few individuals have as yet been produced beyond the first cross. A majority of the half-bloods

show the infusion of foreign blood in color markings, general conformation, and increased weight. They appear to equal the native cattle in hardiness and to respond more rapidly to better care and feeding. Milk records have been secured on only one half-blood cow, in which case the yield and the length of the lactation period show a great improvement over the average native cow. Additional data on this phase of the work will be secured as soon as other half-blood heifers calve.

The records covering the period from the inception of the project to the close of the fiscal year 1917 show that 108 privately-owned native cows were bred to the pure-blood Ayrshires, while it is estimated that at least 200 native cows have been bred to the station grade bulls. In the latter case the general practice was to allow the bull free range with various herds and the estimate is based upon the total number of cows in each herd, reports of owners and caretakers, and actual count of the offspring at various periods.

Past experience has shown that under present conditions a greater part of the work must be accomplished through the placing of sires out over the island rather than by the practice of maintaining the sires for public service at the Government stations. A majority of the native cows run in herds, generally in remote and not easily accessible districts where they are often very wild. Under these conditions it is a difficult task to bring them into the station for breeding. It is also considered that in most instances greater good can be accomplished if the station retains the ownership of these sires.

Three station grade bulls are loaned out at present. It is planned to place three more this year, and a number of younger ones on hand now will be available within the next two or three years. (Pl. III, fig. 1.)

The experience at the Cotot stock farm has shown the benefits to be derived from pasture improvement and tick-control work. A grazing area of approximately 35 acres of upland native pasture and 100 acres of woodland pasture was insufficient, particularly during the dry season, to keep the herd of 15 native cows in condition. It was found that in order to properly continue the work it would be absolutely necessary to provide improved pastures. It was also found that at certain times it was impossible to keep the cattle in condition without employing efficient methods of tick control. In this connection it should be noted that the grade calves often carry comparatively heavy coats, a characteristic especially conducive to tick infestation.

Improved pastures.—The greater part of the available grazing area of the island consists of the poorer upland pastures. It is known that during each dry season a number of aged cows and weanling calves ranging on these pastures die from a shortage of pasture and

the effect of ticks. There is no doubt but that in order to bring about satisfactory improvement in the cattle industry of the island improved pastures must be provided and tick control measures employed.

Para and Paspalum have been employed in the pasture-improvement work at both the Cotot and Piti stations. The areas provided, aside from those necessary for general pasture and soiling purposes, have been insufficient to permit extensive pasture tests. As given in last year's report, a definite test was conducted at Cotot showing the superiority for cattle of Para over the native pasture. General observations at this station have also shown the comparative excellence of this forage. In a number of instances cows which became very thin from running on native pastures have rapidly developed into good condition when transferred to the Para.

Experience has shown the necessity of allowing new plantings of Para or Paspalum to become well established before pasturing them. Paspalum will stand much more extensive pasturing than Para, but appears to be less palatable to cattle.

WORK FOR 1918.

General herd notes.—The lines of work directed toward the production of station grade cattle and the upgrading of native range stock have progressed quite satisfactorily during the year. Only two deaths have occurred among the station's native and grade animals. A number of cross-bred calves, including 2 three-quarter-blood Ayrshires, have been dropped, and all the cows and heifers of breeding age in the Cotot herd with the exception of two head were with calf at the close of the year.

Of the grade bulls loaned for public breeding two have remained in the same district as reported last year, while the other (No. 35) was transferred from the municipality of Agat and placed with the island government's herd at the Libugan Farm near Agana. There is a total of approximately 160 cows and heifers of breeding age in the herds headed by these grade sires.

One death occurred among the pure-blood Ayrshires, that of the bull Harry Gray No. 14. As noted in previous reports, this animal showed periods of illness upon each occasion of his transfer from the Piti station to the Cotot stock farm. Upon being returned to Piti the animal would apparently recover, although he never showed proper condition and development after the first period of illness. Previous periods of illness were attributed to tick infestation, but during the time the bull was stationed at Cotot the past year he was kept practically tick free; at least he did not carry any more ticks than he had at various times while at Piti, in which

instances he had shown no ill effects from the slight infestations. Just previous to the fatal period of illness the animal was apparently recovering satisfactorily from an earlier and comparatively moderate attack. When his condition became worse again the case developed so rapidly that it was impracticable to return the animal to Piti.

Pathological specimens from this bull were submitted to the Bureau of Agriculture, Manila, for examination. The report relative to the matter stated that although from the material submitted it was not possible to make a definite diagnosis, the specimens presented indications of a slow forage poisoning.[1]

Since the establishment of the Cotot stock farm there have been on hand only two pure-blood bulls, and as it has always been considered inadvisable to attempt to station the imported bull John Gray at Cotot, it has been necessary to use Harry Gray in the upgrading work at that station. The distance of the farm from the Piti station and the condition of the trail leading thereto make it impracticable to bring the cows to the latter station for service.

Since the death of the bull in question the young three-quarter-blood bull No. 44 has been at the head of the Cotot herd. The bull John Gray No. 3, mentioned in the last annual report as showing at the close of the year a slight illness characterized by a weakness of the hind quarters, has been in such condition as to render him unserviceable for a greater portion of the year. During the month of July his condition became more serious, there being times when he was unable to assume a standing position. After a few weeks there was an improvement so far as the weakness was concerned, but there was a gradual loss of weight due to inappetence. Beginning with the latter part of September the animal showed a steady improvement, there being a gradual gain in flesh to nearly normal condition. The weakened condition of the hind quarters is still very noticeable, however, making it difficult for the animal to move about. Various unsuccessful attempts have been made to diagnose the case and to relieve the condition.

The pure-blood herd has been increased by one birth, the first of the third generation of Guam-born Ayrshires. (Pl. III, fig. 2.) The cows Red Rose No. 5 and Guam Island Rose No. 10, which have been barren for some time, are still in this condition. Milk records have been secured of the Guam-grown Ayrshire cow Baby Rose No. 41 at her first calving and of the aged grade Jersey cow No. 1 (⅛ Jersey, ⅞ native). The average daily yield of the former for a 242-day period was 13.62 pounds, and of the latter for the same period 12.91 pounds. The average of butter-fat tests taken during the first and latter parts of this period was 4.6 per cent in the case of the

[1] The specimens were sent to Dr. S. Youngberg, chief veterinarian, Bureau of Agriculture, and were examined by Dr. W. H. Boynton, pathologist of the same bureau.

FIG. 1.—HALF-BLOOD AYRSHIRE BULLS.

FIG. 2.—PURE-BLOOD AYRSHIRE FEMALE CALF, FIRST OF THIRD GENERATION OF GUAM-RAISED AYRSHIRES.

Ayrshire and 5.7 per cent in the case of the grade Jersey. The roughage ration of each animal consisted of Para and Paspalum, in addition to which a comparatively light grain ration was fed. For one month of the period chopped uncooked breadfruit (seedless variety) was substituted for a large portion of the regular daily grain ration. There was a slight decrease in the milk yield following the substitution, but this was thought to have been due to the stage of the lactation period rather than to the change of feed. Breadfruit foliage is relished by all cattle.

Improved pastures.—The absence of a definite dry season during the year has made it impossible to do any extensive burning of brush in connection with the clearing of land for the extension of improved pastures at Cotot.

An observation at this station during the latter part of the year would tend to show the comparable palatability to cattle of Para and Paspalum pastures. A part of the herd had access to a field one-half of the area of which was devoted to Para and the remainder to Paspalum. The Para portion of the field was closely pastured by the herd before the Paspalum was grazed to any extent.

In connection with the data relative to the carrying capacity of improved pastures, it should be noted that during the past two years, throughout which there was no prolonged dry season, 2.25 acres of Paspalum has supported two head of mature carabao with an apparently uninjured stand. A Para pasture comprising approximately three-fourths acre furnished sufficient pasture for two yearling bulls for a period of 8 months during the past fiscal period, but in this case the stand was damaged, showing the unadvisability of such heavy pasturing.

A pasture test conducted at Cotot to compare the efficiency of Para and native grass pastures was concluded in August. The test was begun on February 14, 1917, and the results obtained up to the close of the fiscal year were given in the last annual report of this station. The animals used in the experiment were seven native cows of about the same age and one grade heifer No. 38. The area of Para pastured was about 5 acres and that of the native grass approximately 130 acres, 35 acres of which was open upland and the remainder woodland, the upland portion of the native pasture consisting mostly of *Andropogon aciculatus.* Although the test was conducted partly during the ordinarily dry season of the year, in this case there were frequent rains throughout the period, and the pasture, especially the native grass area, showed better growth than it would have under the mere pronounced dry-season conditions.

In this instance the 4 cows placed on the Para lot were formerly pastured on the native range and the other 4 were formerly on Para

pasture. The chief import of the test is shown not so much by a comparison of the two lots as from a consideration of each individual case which shows a very decided gain in weight in the transfer of the animal from the native to the Para pasture and a loss in the case of each animal when transferred from Para to native pasture. In connection with this test some allowance should be made for the fact that cows Nos. 20, 26, and 30 were bred during the period covered by the experiment. Of these, Nos. 20 and 26 dropped calves in January and No. 30 in February.

In the table below is shown the total of results in connection with this test:

Comparative values of Para grass and native pastures.

Cow No.	Lot No. 1, Para pasture.				Cow No.	Lot No. 2, native pasture.			
	Weight, Feb. 14.	Weight, June 29.	Weight, Aug. 15.	Gain in weight.		Weight, Feb. 14.	Weight, June 29.	Weight, Aug. 15.	Loss in weight.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
20	432	520	583	151	12	569	437	424	145
30	497	551	593	96	17	510	366	330	180
31	359	485	578	219	18	624	519	495	129
38	324	462	514	190	26	620	579	585	35

Number of animals on hand.—The following table shows the number of animals on hand at the close of the year:

Number of cattle in station herd.

Breed.	Bulls.	Cows.	Young stock.		Calves.	
			Males.	Females.	Males.	Females.
Ayrshire	1	3	.....	1	.....	.....
Grade Ayrshire	4	2	4	9	3	3
Grade Jersey	.....	2	.....	.....	.....	.....
Native	.....	14	.....	.....	.....	.....
Total	5	21	4	10	3	3

SWINE.

HISTORY OF THE WORK.

The latest census shows a total of approximately 3,500 head of swine on the island. Among this number two distinct types are easily recognized, the one termed "chabot," or chunky, and the other the "lanza," or rangy, type. As there is no concerted effort to keep these classes distinct, there are also individuals showing various gradations between these two types. Animals of the chabot class are of the extreme lard type in conformation, and are preferred by the Chamorro

farmer to those of the rangy class, as they are more easily fattened and produce a higher percentage of fat which is highly prized for the production of lard. Among these native pigs there is a great variation in size, but in general the weight of the average mature animal is considerably less than that of the average pure-bred or improved grade pig. Their most objectionable characteristic, however, is their slow rate of growth or development.

As with cattle and most other animals the pigs are given very little care by the Chamorro farmer, practically no attention being paid to selection of breeding stock. Fenced runs or pastures are very seldom provided, the more common practice being to keep the animals tied up under a ranch building or shade tree with a rope secured to the fore leg. Sometimes they are kept in small pens. In some districts they are allowed to run in the woods, the only feed given, if any, being cooked taro tops. Other common feeds are taro roots, the butts of banana stalks, and breadfruit and coconuts when in season. The first two and the seedless variety of the breadfruit are generally fed cooked. Animals kept about the yards also receive kitchen slops. Corn is sometimes fed, but very sparingly because of the demand for it as food, and because of a lack of proper storage facilities, this making the corn available in sufficient quantities for general use as a stock feed only during and for a short time following harvest.

The present number of swine raised is not nearly sufficient to meet even the demand of the native population. Very little native pork is sold in the Government market, a greater number of the animals being sold on the hoof for feast purposes or slaughtered from time to time and divided among the neighboring families. Animals disposed of in this manner are seldom weighed, the price generally being fixed according to the size of the animal. In this case it is estimated that the price will average from 10 to 12 cents per pound live weight.

That the number of pigs produced is limited is due primarily to the presence of certain diseases and the fact that the average Chamorro does not realize that their successful production requires that the animals be given special attention involving the growing and use of a variety of suitable feeds. The prevalence of kidney worm (*Stephanurus dentatus*), lung worm (*Metastrongylus apri*), and cholera probably constitutes the greatest present obstacle to swine production. A proper development of this phase of stock raising on the island necessitates, along with the employment of better methods of care and handling, an improvement in the size, conformation, and maturing qualities of the native swine.

In order to establish a station herd for the production of stock for experimental purposes and improved breeding animals for distribution, a shipment of 4 head of pure-blood Berkshires (2 boars and 2 sows) was made to the island in October, 1911. The production of

pure bloods from this importation was unsuccessful, as the two boars and one sow died about 18 months after the date of their introduction and in the meantime the two sows had failed to breed. The remaining sow died in 1915, having failed to raise any offspring.

Previous to the death of the two boars a number of half-blood pigs had been raised by mating one of the boars with two native sows owned by the station. Five sows had been selected from this number and bred to the unrelated boar. These half-blood sows retained for breeding purposes represent the initial work, continued up to the present time, directed toward the establishment of a station breeding herd by successive crossings of the Berkshire on the native and grade stock and the production of improved grade animals for sale to the public. That part of the work dealing with the establishment of a station herd was delayed through the difficulty experienced in securing additional pure-blood breeding stock. It was not until December, 1915, that the second shipment of Berkshires consisting of two young boars was received.

From the inception of the project to the beginning of the past fiscal year 153 grade pigs (66 males and 87 females) have been raised. Of this number 69 were sold for breeding purposes with the exception of a few head. During the period, 19 of the number raised died from disease, 11 of the deaths being due to internal parasites and 8 to undetermined causes. The parasites most frequently encountered were the kidney and lung worms already mentioned.

The Berkshire has proved well adapted for crossing with the native stock. With rare exceptions the grade animals show a marked improvement over the native stock in size, conformation, and early maturing qualities. If given even fair treatment the half and three-quarter bloods appear to equal the native pigs in hardiness. It may be that the improved pig will not survive the extreme adverse conditions to which some native pigs are subjected. However, swine raising under such a system is wholly unprofitable.

Up to the close of the fiscal year 1917 no pigs had been produced beyond the second cross. As would be expected, the improvement, in size and general conformation at least, was much more noticeable in the first than in the second cross offspring. The litters of both crosses seem to show more unevenness in development than is the case with pure native pigs or with the pure-blood and grade pigs of the States. The best growing period for young pigs seems to be from November to March. Parasites and other diseases appear to be most troublesome at the beginning of the period of heavy rains.

Aside from the native stock improvement work accomplished through the sale of breeding animals during the period in question, a number of privately owned native sows were bred to the station pure-blood and grade boars. At present there are few hogs raised within

the immediate vicinity of the station, and judging from the experience of the past two years a greater part of the upgrading work must necessarily be accomplished through the distribution of the improved stock.

Regarding the subject of feeds and feeding, the high cost of feeds and the difficulty involved in their importation make the work of determining suitable local rations of prime importance in connection with the growing of swine on the island. From tests conducted it was found that a considerable portion at least of the ration of imported grains can be substituted with cooked breadfruit and grated raw coconut. Taro was tested as a ration substitute, but the experiment was not conducted for a sufficient length of time to warrant the drawing of definite conclusions. Pasture tests were conducted which indicated that Para grass is superior to the average native pasture for growing pigs. This grass has also proved a satisfactory pasture for brood sows. In a test of short duration, cowpeas gave promise of being a suitable pasture forage.

WORK FOR 1918.

During the year, 29 grade pigs and three mature grade animals were sold to the public for breeding purposes. The increase numbered 24 head of grades. The losses consisted of 4 mature animals and 16 suckling pigs. The deaths among the mature animals included the two imported Berkshire boars, the only pure-blood animals on the island. This constitutes a serious loss, principally because of the delay that will be caused in the work of establishing a station breeding herd. It is also especially to be regretted that five of the grade brood sows which were bred to the last boar a short time previous to his death failed to get with pig. Until other pure-blood sires can be secured, grade boars will be used in the production of stock for experimental work and for distribution for breeding purposes.

A majority of the deaths among the suckling pigs was caused by scours due to mammitis in the dams. With the possible exception of one case, so far as known, no losses were sustained from internal parasites.

One three-quarter-blood boar was loaned for public breeding for a portion of the year, during which time 30 native sows were bred to him. Only a few privately owned sows have been brought to the station for service. In connection with the public swine improvement work, it is not considered advisable to make a general practice of loaning boars. Without field assistants it is impossible to properly superintend the management of these sires and the purchase of this class of stock is within the means of the average

farmer; also most farmers prefer to purchase animals rather than accept the loan of them.

During the year the half-blood sows of the previous breeding herd were replaced with selected young three-quarter-blood sows. (Pl. IV, fig. 1.) There are also on hand 4 seven-eighths-blood female pigs which, with the use of a pure-blood boar, will make possible the production within a short time of practically a pure-blood herd.

Breadfruit and coconut as part substitutes for the grain ration.—The test begun on May 1 of the year previous, in which the object was to secure additional data in connection with the work of determining to what extent the grain ration of swine may be substituted with breadfruit and coconut, was concluded at the close of a 92-day period. The results of the experiment up to the close of the last fiscal year have already been published.[1]

Two lots of 6 growing pigs (on account of sickness one was eliminated soon after the test was begun) each were used in this test. Those of lot No. 1 received an average daily ration for the period of 2.5 pounds per head of mixed grains, while each animal of lot No. 2 received one-half this amount of grain in addition to 2 pounds cooked breadfruit (seedless variety) and two-thirds pound grated coconut. The lot receiving the entire grain ration made a total gain of 6.3 pounds per head more than the lot receiving the part breadfruit and coconut ration. However, when cost of feeds is considered, the latter was much the more economical ration. Both lots were run on Para grass pasture throughout the test.

Jack beans and velvet beans as pasture crops for swine.—In pasture tests with both growing pigs and mature sows neither the vines nor fruits of jack beans at any stage were eaten, while the velvet beans were eaten readily by brood sows but only sparingly by growing pigs. The total of results and observations would seem to indicate that jack beans are entirely unsuitable as a pasture crop for either pigs or mature swine, while the velvet beans gave sufficient promise to warrant further trial.

Comparative rate of development of native and half-blood pigs.—An experiment to determine the comparative rate of growth of half-blood and pure-native pigs was conducted over a period of 185 days. Six native (one native pig died during the progress of the test, and is not taken into consideration in the final results) and 6 half-blood pigs about four months of age were used in the test. Both groups or classes were kept on Para pasture and received the same amount of grain daily and the same care and treatment otherwise. At the close of the 185-day period the average gain of the grade lot was 78.7 pounds, while that of the native was only 37.8 pounds. (Pl. IV,

[1] Guam Sta. Rpt. 1917, p. 12.

fig. 2.) A slaughter test was afterward conducted with two of the grade barrows and the same number of native barrows. All four animals gave a comparatively high dressing percentage. There was not so great a difference in favor of the grades in this respect as was anticipated, due perhaps to the fact that the grade lot were in good flesh, while the latter were too fat. The meat of the two native barrows contained a high percentage of fat and was otherwise inferior both in flavor and texture to that of the two grades. As previously mentioned, however, the overly fat carcass is not objected to by the average Chamorro.

Comparison of pasture and tethering method of handling swine.—Eight native pigs, 6 barrows and 2 females, of about three months of age, were selected and divided into two as nearly equal lots as possible. Those of one lot were tethered in well-shaded locations in accordance with the very common Chamorro custom. The other lot was run on a pasture of about one-fourth acre of velvet beans and Para grass. Both lots were otherwise given the same care and treatment. The ration fed twice daily consisted of a mixture of cooked breadfruit and grated coconut. At the close of the year—at the end of a period of 56 days—the lot having access to the pasture had made an average gain of 9 pounds more than the four pigs which were tethered and had access to no green feed other than the fruit mentioned. This test will be continued.

Number of swine on hand.—The following table shows the number of each class of swine on hand at the close of the year:

Number of swine in station herd.

Kind of swine.	Boars.	Sows.	Pigs.		Total.
			Males.	Females.	
Quarter-blood				2	2
Half-blood		5			5
Five-eighths-blood				3	3
Three-quarter-blood	1	6			7
Seven-eighths-blood			2	4	6
Native		1			1
Total	1	12	2	9	24

CHICKENS.

HISTORY OF PREVIOUS WORK.

The native chickens of the island are for the most part a miscellaneous mixture of varieties. There are no definite breeds, although among the number are a few groups or classes the individuals of which possess one or more distinct characteristics. Those of one class are distinguished by a ruffled plumage, those of another by a

black skin and meat, being known as "black meat" chickens, while still another, termed "Saigons," resemble Malay games somewhat.

Native hens average about 3.5 pounds in weight and the cocks about 2 pounds heavier. The hens are poor layers, very much inclined to broodiness, and their eggs are small as compared with those of the improved breeds.

There is a good local market for chickens and eggs at all times. Although nearly every rancher keeps a few fowls, poultry raising is not conducted on a commercial scale by anyone.

The chief obstacles to poultry raising are the presence of serious contagious diseases and the difficulty encountered in securing suitable local feeds in quantity. There is also a general lack of knowledge relative to proper methods of care and handling of stock. Among the prevalent diseases chicken pox is probably the most troublesome. The fact that no contagious or infectious diseases have been present among the station chickens for the past two years and a half would seem to indicate the possibility of keeping flocks free of disease by isolating them from other fowls of the neighborhood.

Introductions.—On October 12, 1911, the station received from the United States a small shipment of pure-blood Plymouth Rocks and single-comb Brown Leghorns, consisting of 6 pullets and 2 cockerels of each breed. The only other introduction received by the station arrived on the island in December, 1915, and comprised 4 Plymouth Rock, 4 single-comb Rhode Island Red, and 6 single-comb, pure-blood Brown Leghorn cockerels. So far as known, the only other introductions of pure-blood or improved chickens since the American occupation of the island consisted of one small shipment of White Leghorns and one of Rhode Island Reds, both imported from Japan by private individuals.

From the use of the station-imported stock considerable work has been accomplished in the production and distribution for breeding purposes of pure-blood and grade chickens and in conducting breeding, feeding, and incubation tests.

Breeding work.—In the cross-breeding work conducted to secure improved stock for distribution and for experimental purposes and to test the comparative suitability of the different breeds for upgrading work, the three breeds previously mentioned as having been imported by the station were crossed with the native stock. Owing principally to the limited size of the station plant and inability to secure new breeding stock at critical times none of these crosses with the exception of the Rhode Island Red has been carried beyond the second generation. In comparing the various classes of half-bloods, or progeny of the first mating, that designated as the No. 5 cross, derived from mating native "black-meat" hens with Brown Leghorn

FIG. 1.—THREE-QUARTER-BLOOD BERKSHIRE BROOD SOWS, AVERAGE WEIGHT 255 POUNDS.

FIG. 2.—NATIVE AND HALF-BLOOD BERKSHIRE PIGS IN COMPARATIVE DEVELOPMENT EXPERIMENT.

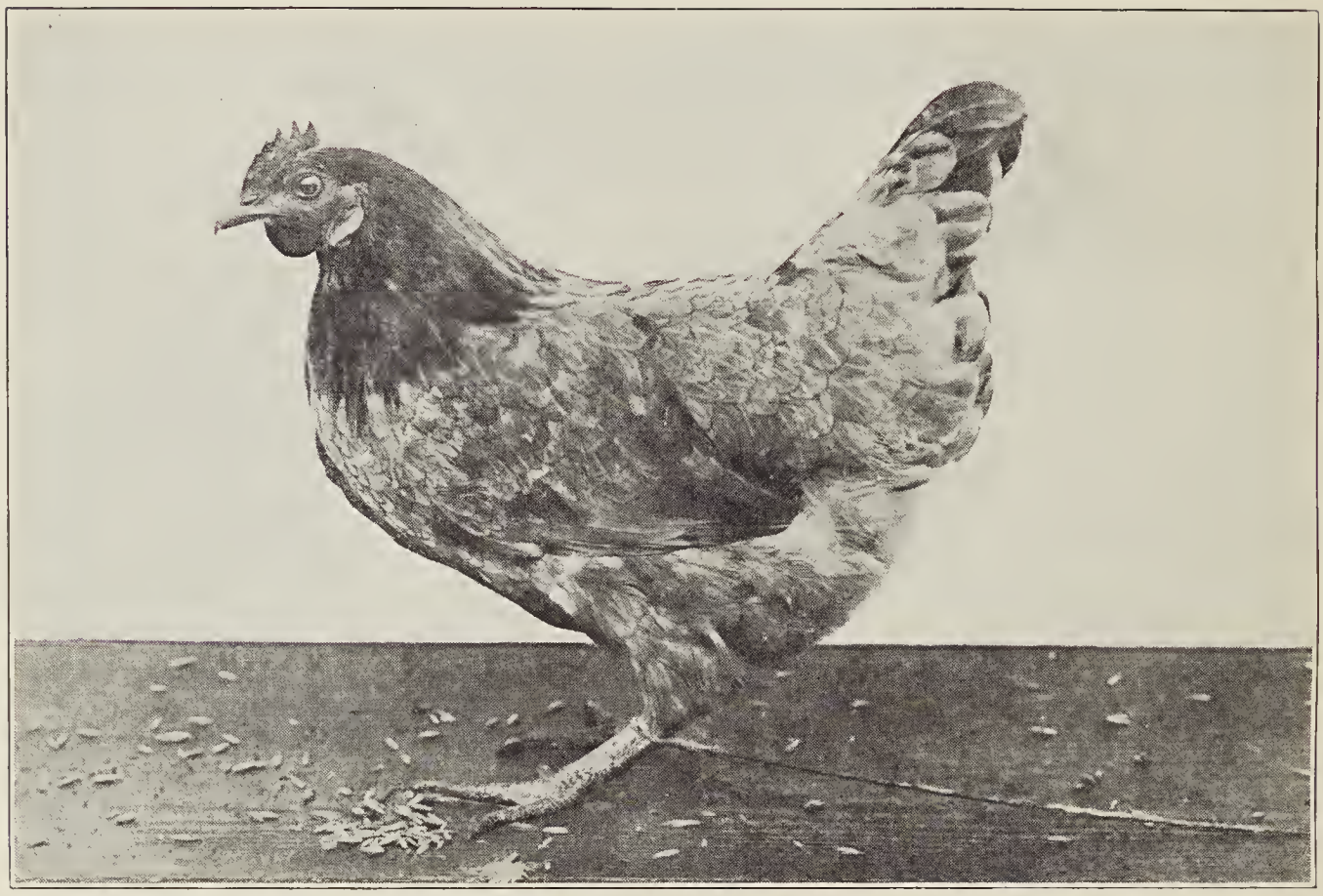

FIG. 1.—RHODE ISLAND RED-NATIVE PULLET (THIRD CROSS).

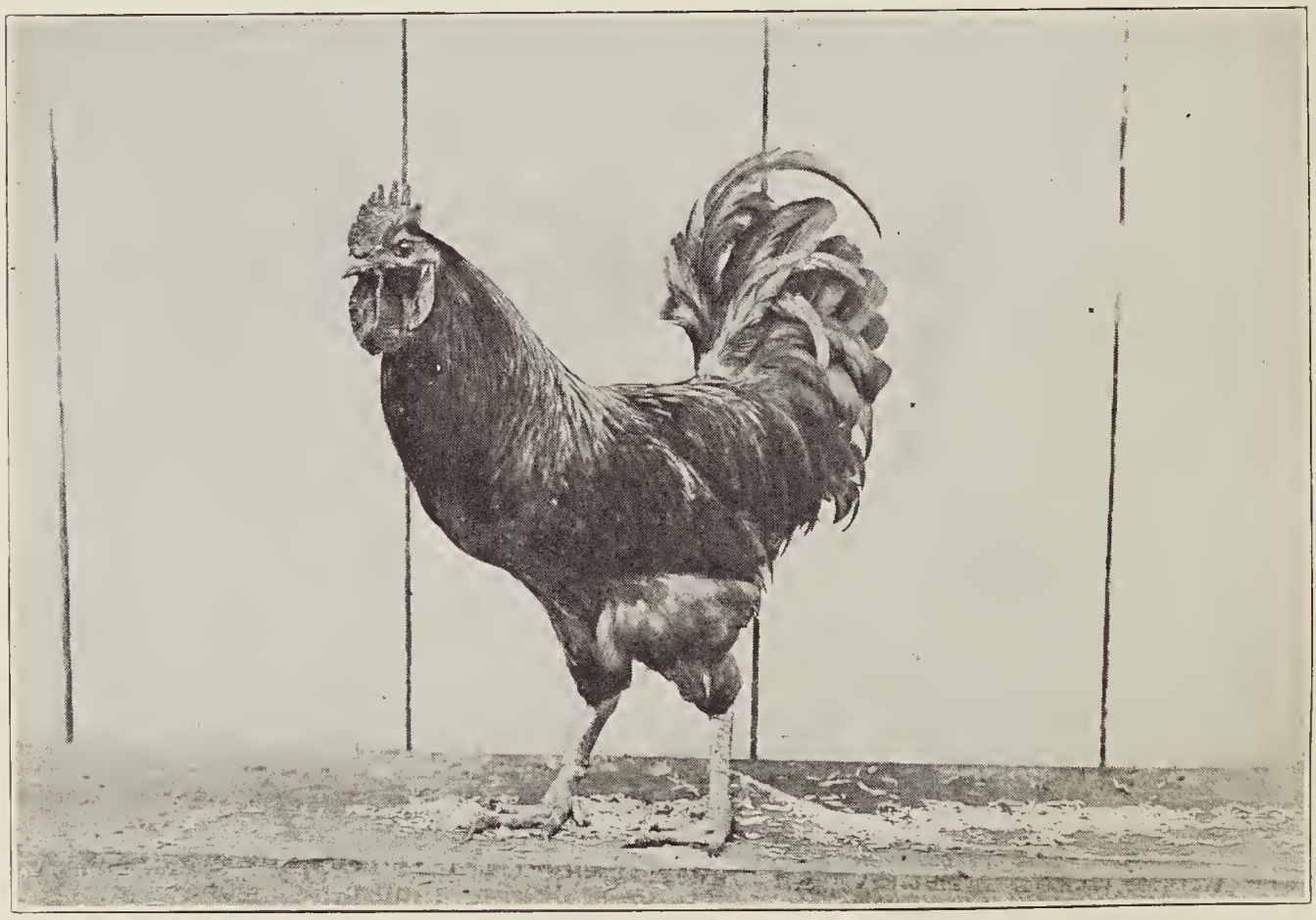

FIG. 2.—RHODE ISLAND RED-NATIVE COCKEREL (THIRD CROSS).

cocks, gave the best egg production, while the No. 11 cross, derived from mating Brown Leghorn hens with native "Saigon" cocks, was second. The No. 12 cross, from Rhode Island Red cocks and native "Saigon" hens, gave the largest fowls of the various classes and produced the largest eggs.

In case of each class of cross-breds, the egg yield (based upon a year's record of ten or more hens) was more than double the average yield of pens of selected native hens. From these records and the opinion of a number of native farmers, it is estimated that the average individual egg yield of the highest laying strains of native hens kept under ordinary ranch conditions will not exceed 40 eggs per annum.

The only cross-bred work being conducted at the present time is with the No. 11, in which the Rhode Island Red breed is being used. The foundation stock in this case was the No. 11 half-bloods, previously mentioned as being the progeny from mating Brown Leghorns and native "Saigons." With this as the foundation blood the Rhode Island Red cross has been carried to the third generation. (Pl. V.) The initial Brown Leghorn cross showed a very marked improvement over the native stock in egg production and size of egg and fowl. The successive Rhode Island Red matings have not produced any material improvement in these characteristics, but in each case there has been a great improvement in uniformity of size, conformation, and color markings.

The results of the work directed toward the improvement of the native chickens of the island accomplished the past few years through the sale and loan of pure-blood and grade stock and the distribution of eggs for setting indicate that the Rhode Island Red crosses are better adapted to local farm conditions than are the Brown Leghorns, Plymouth Rocks, or their crosses.

In the work with pure-bloods there appears to be a decrease in size of egg and fowl with each successive locally grown generation. However, more work will have to be accomplished in this direction before definite conclusions can be drawn.

Incubation tests.—The incubators used are a standard type of hot-air machine. Better results have been obtained by maintaining in the egg chamber a temperature from 100 to 102° F. rather than the usual temperature of 103°. Although these incubators are non-moisture machines, the hatch, especially during the dry season, is apparently benefited by sprinkling the concrete floor under the machines with water twice daily during the last week of the incubation period.

Tests extending over a number of seasons show that eggs intended for hatching purposes when kept in a closed building should not be

held for a longer period than from 7 to 10 days, depending upon the time of year. The best season for the hatching and brooding of chicks seems to be from November to March.

Brooding tests.—A number of experiments have been conducted comparing the efficiency of a standard kerosene-heated brooder, different types of homemade box or fireless brooders, and the system of keeping the chicks in a compartment on the brooder house floor without a brooder. No tests have been carried on with out-door methods of brooding. The work has shown the necessity for best results of using some sort of brooder even during the hot season. During the cool season the artificially heated brooder gave slightly better results than the box brooders, while during other seasons of the year there was practically no difference between the results obtained with the two systems. It is doubtful whether the difference in favor of the heated brooder is sufficient to compensate for the greater cost of the machine and the expense of operation as compared with the box brooder.

The records show that at one time it was considered advisable to keep the chicks in the brooder house during the brooding period of 6 weeks, as they seemed more liable to become diseased if allowed to run on the ground during this period. For the past two years no trouble of this nature has been experienced, and in general chicks having access to ground runs have made better growth than those confined to the brooder house.

Feeding tests.—Most of the feeding tests have been conducted with the object of determining suitable combinations of locally grown feeds to take the place of rations composed of imported feeds. As has been mentioned in connection with the feeding work conducted with other classes of live stock, the chief obstacle is the difficulty encountered in securing throughout the year certain feeds in quantity. It would seem, however, that satisfactory combinations could be made up from the number of locally adapted grains, legumes, root crops, and fruits.

Palay or unhulled rice as a scratch feed and a mixture of corn meal, cowpea meal, and fresh meat scrap as a mash have been satisfactorily used for laying hens in place of rations composed of imported feeds.

Fresh grated coconut is very commonly used by the farmers of the island as a feed, especially for chicks. It is often the only feed given to the chickens, which in all cases, however, have free range. In a number of tests conducted by the station, ill effects followed when chicks which were confined to the brooder house were fed grated coconut in greater amounts than 5 per cent by weight of the total ration. Chicks in large runs showed ill effects when the coconut composed more than 10 per cent of the total ration fed.

WORK FOR 1918.

The work of the year under this project has been confined chiefly to the development of the station breeding flocks of Brown Leghorn and Rhode Island Red crosses and the production of breeding stock for distribution.

In the incubation work the percentage of hatch throughout the season was comparatively low. On the other hand, the chicks have in general been strong and vigorous, the hatches have developed more evenly than was the case the year previous, and the mortality of chicks under 12 weeks of age has been unusually low. Home-made fireless or box brooders were used exclusively in handling the incubator chicks.

Age of egg test.—This test was continued, the data being collected with the object of determining the maximum length of time advisable for keeping eggs on hand for incubation. The results of the season agree in general with those obtained the year previous. These data show that eggs intended for incubation and kept under conditions similar to those obtaining in connection with these tests should not be held for a longer period than from 7 to 10 days, depending upon the season of the year. In all these tests the eggs were kept in a poorly ventilated unceiled room, in a building having an iron roof. The temperature in this room was considerably higher than would be the case in the thatched house of open construction and other buildings found on the average Chamorro ranch. Eggs intended for incubation could no doubt be safely held in the latter type of building a few days longer than the period indicated as advisable by the tests in question.

Natural versus artificial incubation.—Chicks hatched by natural incubation and kept with the mothers on ground runs made better gains than incubator-hatched chicks.

Papayas proved very satisfactory for planting in the chicken yards and runs. The trees furnish suitable shade and the ripe fruit is relished by chicks and older fowls alike.

GOATS.

HISTORY OF PREVIOUS WORK.

Native goats are found quite generally distributed throughout the island. They are of a mixed variety, no definite type being represented. In general they are poor milkers, although occasionally a fair producing individual is found. The Chamorro people make use of these goats for milk and meat purposes only to a limited extent, keeping them chiefly as pets.

A few head of good type goats could advantageously be kept by the average native family, principally for milk purposes. The prod-

uct would fill a want in the present native diet. The low cost of maintenance and the quickness and ease with which they can be produced make them particularly well adapted for maintenance in cases where the facilities and means would not admit of the keeping of milch cows. It would seem that the situation would warrant work toward the improvement, especially of the milking qualities, of the present goats of the island. One of the principal means of accomplishing this improvement is through the infusion of the blood of good milch breeds.

According to the best available information, the first improved goats were introduced from Japan in 1911, the introduction consisting of one buck and one doe. The former was apparently a grade Toggenburg and the latter a pure-blood, or at least a high-grade, Saanen. A number of grade goats showing a strain of the blood of these imported animals are to be found on the island.

During the latter part of the fiscal year 1914 the station purchased one grade Saanen and 9 native does, while the above mentioned imported doe and one grade Saanen buck were presented to the station. These animals formed the foundation herd with which work has been carried on toward the development of an improved breeding herd, the surplus of suitable grade animals produced being distributed throughout the island for breeding purposes.

In December, 1915, two young pure-bred Toggenburg bucks were imported to head the station herd of grade and native does. Soon after the arrival of this introduction, the nodular worm disease (*Œsophagostomum columbianum*) and the fourth stomach worm (*Hæmonchus contortus*) appeared in the herd. A number of deaths, including one of the imported bucks, occurred from the effects of these parasites. During the fiscal year 1917 the remaining Toggenburg buck died from liver-fluke infestation. Principally through the isolation and placing of animals in dry lots and through the systematic rotation of pastures, these diseases were gradually overcome for the most part. Very few cases have been lost from internal parasites since the middle of the fiscal year 1917. In this connection it should be noted that parasitic diseases seem to give very little trouble in the cases where only a small number of goats are kept about the houses or the ranch.

Aside from the presence of disease the work has been delayed through inability to secure additional pure-bred Toggenburg sires. Following the death of the second stud sire, half-blood bucks have been used in the herd breeding work.

With but very few exceptions the offspring of the first cross of the Toggenburg with the native stock show color markings typical of the pure-blood. (Pl. VI, fig. 1.) The quarter-bloods do not resemble the pure-bred in this respect except in case of a few individuals and

FIG. 1.—HALF-BLOOD TOGGENBURG BUCK, WEIGHT 110 POUNDS.

FIG. 2.— QUARTER-BLOOD TOGGENBURG KIDS.

then only in the solid brown body color. (Pl. VI, fig. 2.) Although only a few actual records have been secured the half-blood seems to show marked improvement over the native in milk yield. In general there is also an increase in size.

WORK FOR 1918.

It was not until July 1, 1917, that any of the half-blood males reached serviceable age. On that date the young buck No. 57 was turned with the breeding herd consisting of 4 native and 4 grade-Saanen does and 1 half-blood Toggenburg doe, also 3 half-blood female Toggenburg kids which became of breeding age during the season. The increase of the year, the get of this sire, comprised 6 female and 8 male quarter-blood and 2 female half-blood Toggenburg kids. The losses consisted of 2 bucks, 4 does, and 4 kids. The death of the four kids was due to whipworms (*Trichuris affinis*) and fourth stomach worms. These were the only losses during the year from internal parasites.

Of the three grade bucks loaned for public breeding, two, Nos. 23 and 34, died, the deaths being included in the above-mentioned losses. The remaining one, No. 2, is still on the Sternburg ranch near Agana. Thirty native does were bred to No. 34 during the year and 40 native and grade-Saanen does to No. 2.

The following table shows the number of goats on hand at the close of the year:

Number of goats in the station herd.

	Bucks.	Does.	Kids.		Total.
			Male.	Female.	
½ Saanen–½ native	1				1
¼ Saanen–¾ native		4			4
Native		3			3
½ Toggenburg–½ native		1			1
⅜ Toggenburg–⅛ Saanen–⅜ native	2	2			4
⅜ Toggenburg–⅛ Saanen–⅝ native			3	3	6
¼ Toggenburg–¾ native			3	1	4
½ Toggenburg–$\frac{1}{16}$Saanen–$\frac{7}{16}$ native				2	2
Total	3	10	6	6	25

REPORT OF THE AGRONOMIST AND HORTICULTURIST.

By Glen Briggs.

AGRONOMY.

INTRODUCTION.

On the whole the agronomic work progressed very satisfactorily during the year, although trying circumstances were encountered at times, due to several causes. Particular attention has been given to rice, corn, legumes, and forage crops at the station, while the

extension work has been entirely along food-production lines, with special emphasis on increased production through larger plantings, better seed selection, and the use of more modern machinery, especially plows and cultivators.

As much of the land on the station which has been longest under cultivation is used for soiling and pasture purposes, it has been necessary to carry on most of the crop work across the river on the newly acquired Moritz property. Results have shown that this land, when cleared of trees, shrubs, and grass, has to be broken and kept fallow for some months before it will grow most crops satisfactorily. This has made an increased amount of labor necessary.

The scope of work has been limited, due to a lack of sufficient draft animals. The station at Piti has only two carabao. When it is remembered that a good carabao can not plow more than an acre a week, it will be easily seen that it takes time to prepare land for a crop and properly cultivate it afterward. As was mentioned above, the area for cultivation has been considerably increased during the year, so that more work animals are badly needed. It is planned to meet this need the coming year by purchase of work bullocks.

FORAGE CROP INVESTIGATIONS.

Grass tests.—The experiments with the two imported grasses, Para and *Paspalum dilatatum*, have been continued during the year. Conclusive data have been secured on most of this work, which will be offered in a separate bulletin in the near future. Paspalum has been rapidly gaining in favor as a pasture grass, having proved its ability to withstand drought and heavy pasturing. It is much more palatable to stock than are the native grasses. It has also been found to grow readily on certain areas, at least of the uplands and hillsides of the savannas. Para grass has continued to form the bulk of the roughage that has been fed to the station live stock. Commercial fertilizers and barnyard manure have greatly increased yields, while renovating the soil by plowing has also been beneficial. This station is recommending the general planting of *Paspalum dilatatum* for pasture and of Para grass on the low wet lands for a soiling[1] and pasture crop.

Grain sorghums.—Climatic conditions were not normal during the past year, as there were frequent rains, which were unfavorable for the best development of these crops.

In the kafir and sorghum ratoon crop tests, four ratoon harvests were made. A comparison of the different ratoon crops shows that the stalks have gradually lost in height and circumference, except the last crop, which was of better quality, being produced during the period of least rain. The table (p. 31) gives a summary of the yields.

[1] A crop cut and fed green to animals in stalls, inclosures, or tethered on ropes.

Comparison of first crop and subsequent ratoon crop yields of kafir and sorghum.

Crop.	Date of harvest.	Yield per acre.	
		Kafir.	Sorghum.
		Tons.	*Tons.*
First	May 21	15.5	8
First ratoon	Aug. 15	7.98	10.4
Second ratoon	Dec. 9	3.88	4.72
Third ratoon	Mar. 18	[a] 2.72	7.05
Fourth ratoon	June 21	6.42	12.76

[a] This yield was considerably reduced by carabao getting into the field when the crop was about half grown.

The fourth ratoon crop was the only one producing any grain. The kafir yielded at the rate of 7.5 bushels of grain and the sorghum 12.3 bushels. While the heads were small, they were compact and fairly well filled. The cultivation of these crops was rather difficult during the wet weather, as the soil had a tendency to run together, becoming so badly packed that it was very hard to work with a cultivator. At one time it was so hard that the surface soil had to be loosened with fosiños before it could be cultivated with a five-shovel cultivator.

A grain sorghum variety test was started in December, but although a good stand was secured the plants all died before reaching a height of 6 inches, probably due to unfavorable soil conditions. (See p. 44.) In January the test was repeated but with better results, although the growth was slow and the plants were very dwarf, beginning, however, to recover to a certain extent near the last of March. The following table gives a comparison of the amount of forage produced by the different varieties:

Results of grain sorghum variety test.

Plat No.	Variety.	Yield of forage per acre.	Plat No.	Variety.	Yield of forage per acre.
		Tons.			*Tons.*
1	Blackhull kafir	3.78	5	Darso	10.50
2	Early kafir	5.33	6	Yellow milo	7.43
3	Dwarf hegari	5.95	7	White milo	10.32
4	Schrock kafir	8.53			

From this table it is seen that the Darso and white milo gave the heaviest yields. The best forage was produced, however, by the Darso and Schrock kafir. The stalks were less coarse and more leaves were present. These last two had earlier demonstrated their ability to withstand or overcome to a certain extent the apparently unfavorable soil conditions mentioned above. They were planted on another area on which three crops had already failed. In this test, the Darso, while very dwarf, gave a yield of 6.43 tons of forage per acre and the Schrock kafir, also dwarf, yielded at the rate of 7.22 tons per acre.

An interesting feature that appeared in these tests was the development of both side branches and suckers on certain crops from the early plantings, while a later planting was entirely free from them. As all were from the same lot of seed planted on similar soils, it would seem that climatic conditions, and not inheritance altogether, caused the abnormalities.

Much trouble was encountered during the year from insect pests. Practically no seed was matured on any of the grain sorghums planted on the new ground. A worm worked at the base of the stalk just under the ground for a while on some of the small plants but did little damage to them. The first heads that formed kernels were attacked by the rice bug (*Leptocorisa varicornis*), which sucked the juice from the kernels. Later, after the stalks were headed out, the European corn borer (*Pyrausta nubilalis*) worked in the stem and did considerable damage. The stems were often badly tunneled. The first noticeable evidences of the insect were the casts on the outside of the holes in the stalk. This was followed by the dead appearance of the head which soon fell over, due to the tunnels weakening the terminal internode, but remained attached to the stalk. The heads that survived the attacks of the above insects were badly damaged by ants, mites, and small spiders, apparently working inside the glumes, preventing the development of the ovule, or later destroying the forming kernel.

Sweet sorghums.—In a test of two varieties of sweet sorghum, Black Amber and, supposedly, Red Amber cane, yields were secured of 8.75 and 13.65 tons of forage per acre, respectively. The latter resembled Mississippi cane when it matured, as it was fully 12 feet high and was clearly not an Amber variety.

Sudan grass.—While this crop has not made exceptionally large yields, it has grown steadily and produced four cuttings during the year. All of the tests made at this station have been in drills, but broadcasting will be tried during the next year. Sudan grass is eaten by all the live stock in a manner that shows it is relished. The table below gives the results of the test up to date. The stubble will be left to determine its value as a permanent crop.

Comparison of yields of different cuttings of Sudan grass planted Jan. 6, 1917.

Cutting.	Date of cutting.	Number of days between cuttings.	Yield of green forage per acre.
			Tons.
First	Apr. 24, 1917	[a] 108	9.83
Second	Aug. 24, 1917	122	4.18
Third	Dec. 24, 1917	122	2.13
Fourth	Mar. 18, 1918	84	3.37
Fifth	June 15, 1918	89	7.8

[a] Number of days from planting.

FIG. 1.—PROPERLY CULTIVATED FIELD OF CORN WHICH MATURED SEED AFTER THE TYPHOON OF JULY 7, 1918.

FIG. 2.—STATION RICE FIELD BEFORE INSECT INVASION.

It will be noticed from the table that Sudan grass, like the grain sorghums, makes the poorest yields during the wet season. During this time it grows slowly and is somewhat dwarfed. This forage may prove a valuable soiling crop to supplement pasture grasses during periods of drought.

Legumes.—Large plantings of several kinds of leguminous plants have been made during the year. They have demonstrated that they have an important place to fill in the agriculture of Guam. They have been found to be especially valuable in problems of soil management here at the station. Some kinds have been used as forage and for pasturing off, while nearly all have been used as cover crops, with a few turned under as green manure. Most of the results are given under cover crops (p. 39), while those used for pasturing off are given in the animal husbandry report.

The alfalfa planted over a year ago on a cascajo hillside is still living and has a healthy appearance, although it makes very slow growth. The soil on this hillside is extremely rich in lime as it is largely made up from disintegrated coral. It is probably only on soils heavily impregnated with calcium and having good drainage that alfalfa may be expected to make any kind of crop. It is doubtful if even these factors will overcome the low altitude and the exceptionally humid climate which are generally considered to be antagonistic to alfalfa production.

Sweet clover of the yellow and white flowered varieties was planted during the year, but only the yellow germinated, and it was evidently mixed as two types of flowers appeared, showing the presence of the annual and biennial varieties. Both kinds have grown slowly. Unfortunately, two cows broke into the field and grazed in this plat just after the clover blossomed. It is doubtful if it will recover sufficiently to allow continuing the test.

COTTON VARIETY TESTS.

Ratoon crops.—This work has been continued with the same varieties as mentioned in last year's report. The rainy season stopped the setting of bolls, but the plants made a vigorous growth until August 29, when all varieties were pruned back to a distance of 15 inches from the ground. For some time after this little growth was made. The pruning killed nearly all of the Hawaiian-Egyptian plants, and although the Arizona-Egyptian plants recovered fairly well they did not produce much cotton. The upland varieties put out growth much faster than the Egyptian, with the exception of the Guam-Egyptian which equaled the upland. The plants were very healthy and vigorous after once getting started but set bolls and matured in a very uneven manner, necessitating a number of light pickings. One entire picking

was lost in June due to a heavy rain. The yields secured from the test were as follows:

Comparison of ratoon crop yields of seed cotton from different varieties.

Type.	Variety.	Yield per acre from picking—						Total yield per acre.
		Jan. 4.	Jan. 26.	Apr. 2.	Apr. 26.	May 3.	May 25.	
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Egyptian...	Hawaiian	.....	.....	.....	.....	.....	.....	.....
Do.....	Arizona	.....	.....	22.5	74.4	.....	55.8	152.7
Do.....	Guam	50	53.7	86.2	93	130.2	186	599.1
Upland.....	Hartsville	60.5	77.4	49.6	93	111.6	148.8	540.9
Do.....	Covington-Toole	62.9	62.9	26.8	74.4	111.6	130.2	468.8
Do.....	Hartsville (second ratoon crop)	17.9	35.8	29.9	74.4	.....	93	251

This shows that the Guam-Egyptian variety gave the largest yields, closely followed by the Hartsville.

During February and March no bolls matured, as it was very rainy. The quality taken as a whole has been below that of last year before the plants were pruned. The yields were probably lighter than they would have been during a normal season having a longer period of dry weather.

The variety called Guam-Egyptian is a misnomer, as it is not an an Egyptian type, but is strictly an upland variety. It is thought that the labels must have been interchanged sometime in the past, thus causing the error. This variety is a stocky, low-growing plant with a good symmetrical shape. It has white flowers and large, round bolls slightly pointed at one end. The lint is only of medium length, being $\frac{3}{4}$ to $1\frac{1}{4}$ inches long.

In the variety test on new land, all the plants were removed. They had been dwarfed and the development of bolls had been so delayed that maturity would have occurred during the rainy season when all cotton would have been lost.

CORN IMPROVEMENT WORK.

Very little systematic work has been done with corn in Guam. As a number of conditions are different from those in most other corn countries, more experimental data are greatly needed. Recognizing this, the station started work during the year on distance of planting, a small test of two varieties from Hawaii, an ear-to-row test with the object of reducing furrow space and increasing shelling percentage, a comparison of the ability of flint *v.* a soft strain of Guam corn to withstand the humid climate and the attack of weevils, green manuring with different legumes, and demonstrations of better farming methods by the use of more modern implements. (See Pl. VII, fig. 1.) The ear-to-row breeding work has been continued as

in previous years with satisfactory results and has been placed on a more scientific basis.

RICE.

The following experiments were undertaken during the year: Variety tests, fertilizer tests, head selection work, and a comparison of newly-broken ground with that continuously cropped to rice for about forty years and the effect of fertilizers on the two. The first two tests are in continuation of the work that the station has been carrying on for some time. After the plats had made a most promising start and up into February when the rice began to head out, it appeared as if there would be a large crop (Pl. VII, fig. 2). Shortly after the kernels began to form it was discovered that an insect (see p. 36) was working upon the crop, sucking the juice from the forming kernels. This same condition prevailed over the whole island, causing the rice crop to be a total loss.

Improved facilities for growing rice.—During the year many improvements were made for growing rice on the station. The new ground was laid out in twentieth-acre plats each surrounded by dikes, those on the north side of the main supply ditch being used for fertilizer experiments and those on the south for variety tests and head selection work. The dam across the Masso River was raised and partly rebuilt, the supply ditch was cleaned and deepened, new laterals were put in to make a better distribution of water as well as to improve the drainage, and new floodgates were placed so that the water could be handled more economically.

Fertilizer tests.—The same fertilizer treatments as have been applied in previous tests were made during the year. Among the fertilizers used nitrate of soda was the only one which gave any noticeable results. The plats treated with this fertilizer remained a darker green and headed out about six days later than the other plats. Due to the insects ruining the rice kernels no grain was harvested.

New versus old ground.—The rice on the new ground made a heavy rank growth reaching a height of four feet or more, while that on the old ground made only a fair growth and was not over three feet high at the tallest.

Variety tests.—The variety test was not carried out as planned, as the rice varieties ordered from the Philippines failed to arrive, leaving only three varieties available to carry on this work, namely, Inantipolo II, a Philippine upland variety; a mixture of two Chinese varieties introduced from Hawaii and grown at Piti last year; and a native variety. The upland rice did very poorly when planted under irrigation. The mixed variety gave promise of a good crop, as did the native variety, and would have formed a

basis for starting head selection work but for the insects ruining the crop.

Insects injurious to rice.—Insects damaged the rice to such an extent that the crop was an entire loss on the whole island. As insects were not known to affect the rice crops some years back,[1] they must have been introduced through the importation of rice for food purposes. Three insects were found affecting the crop. These were raised in breeding cages and whole or partial life histories were secured. The following paragraphs describe these in the order of their damage to the rice crop.

Of the three insects mentioned, the rice bug is by far the most common and destructive. From material at hand this insect was identified as the rice bug of India (*Leptocorisa varicornis*) (Pl. VIII, fig. 1), which identification was later confirmed by the Bureau of Entomology of the United States Department of Agriculture. The following information is taken from an article on the rice bug by a noted entomologist[2] and is believed to be the most authentic information available in regard to this insect:

> All previous records and all official reports relate to damage to rice in almost every case when the grain was forming and the seeds are full of milky juice. This form of damage may be constantly observed to a greater or less extent in rice fields probably every year. The bugs fasten on the rice ears [heads] and suck out seed after seed; such ears turn wholly white or partly white, little or no grain being formed. A field badly infested can be detected by the number of these white ears, but one can readily confuse this form of damage with that caused by stem borers; in the latter case the whole stalk and ear withers from below; in the former, only the grains die and the ear is empty but the stalk quite sound. (Pl. VIII, fig. 2.)

The following information is from a publication[3] based on the article above:

> The rice bug is the same insect that in Ceylon is known as the paddy fly, and causes great damage to local crops. Indeed the necessity for rigid observance of seasons in paddy cultivation is chiefly due to the attack of fly which an out-of-season crop is invariably subjected to. An Indian report (by Mr. H. Maxwell-Lefroy, the Imperial Entomologist) contains a very full account of the pest, its distribution, habits, and life history, as well as the method of combating it; and the information given below is mainly abstracted from that report.
>
> The scientific name of the rice bug is *Leptocorisa varicornis*, and the genus is believed to include three species; but the points of distinction are very slight, and probably do not imply any difference in life history. The bug is commonly found in long grass and thick vegetation, being present here singly. It is only at special times and on special crops, such as paddy, that it occurs gregariously. The morning and evening are its most active periods, and during the

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[1] Guam Sta. Rpt. 1911, p. 28.

[2] Lefroy, H. M. The rice bug (*Leptocorisa varicornis*). Mem. Dept. Agr. India, Ent. Ser., 2 (1908), No. 1, pp. 13, pl. 1.

[3] Drieberg, C. The rice bug or paddy fly. Ceylon Agr. Soc. [Pub.] 40 (1909), pp. 2, fig. 1.

FIG. 1.—ADULT RICE BUG (LEPTOCORISA VARICORNIS) ×3.
(AFTER H. M. LEFROY.)

FIG. 2.—RICE FIELD SHOWING CHARACTERISTIC WHITE HEADS CAUSED BY RICE-BUG ATTACKS.

hot part of the day it goes deep into shelter. As all who are familiar with the insect know, it is colored green, and associated with an objectionable odor, being hence sometimes called the "green bug." Its normal food is the sap of flowering shoots of grasses. When infesting paddy, it feeds on the tender developing grain, which is full of milky sap. The dark-brown eggs are laid on leaves in clusters or rows and number from 24 to 30. They are protected by a gummy substance, which helps to attach them to the leaves and prevents their being washed away by rain. The eggs take from six to eight days to hatch out. Between hatching and maturity the nymph passes through five stages, occupying, say, about 18 days, during which time the wings are gradually developed. It is not exactly known how long the imago, or fully developed insect, lives, but insects have been kept alive in captivation for three months. The following is an actual record: Eggs hatched on September 2, adults reared on [September] 18, and lived until November 2. Of enemies to the rice bug there are two known: *Cicindela sexpuncta* which is abundant in rice fields in India from August to October. This is a flying insect and destroys the rice bug in numbers. Another is an egg parasite, which has not been described as yet. Ordinarily the bug occupies a life cycle of from four to five weeks in warm weather, breeds freely with the rains and feeds on rice, dry grain, and grass. There are apparently five broods, depending, however, on local conditions, food supply, etc. With cool weather the insect leaves the open field and goes into the denser shelter of uncultivated land. There is nothing to show that it breeds again till the following rains.

We now come to the most practical part of the circular, namely, that referring to treatment. (1) There is the treatment resting upon superstition, and consisting of "mantras" or charms. This may be put down as utterly useless. (2) Smoking by burning aromatic herbs and resinous substances to windward. This is only a temporary remedy and, though useful in saving individual fields, merely shifts the enemy. (3) Ropes saturated with resin or kerosene or fish oil are drawn over the fields so as to brush against the ears of paddy. This is rather more effectual than the last. (4) A paddy winnow smeared over with some glutinous substance like birdlime (e. g., jak milk) is tied to a long pole and passed over the heads of paddy, so that the insects are caught in large numbers on the sticky substance on the winnow. The process has to be repeated over and over again. It is tedious, but simple and effective. (5) An elongated cloth bag is run across the field sweeping in the bugs as they rise. The bag is either soaked in crude oil emulsion (1 pint emulsion to 2 gallons water) or the inside smeared with something sticky. A bag 8 feet wide and 3 feet high is a convenient size, the sides kept open by bamboos 3 feet long, which serve as handles for grasping it. The width is about as much as two men can run with. A smaller bag may be suspended by ropes. Mr. Lefroy strongly recommends such an appliance and doubts whether any better will be found. The work is best done by cooperation and the treatment of areas together, as bags cost something to make. (6) It has been found that a mixture of bran and jaggery [1] serves as a bait for the bugs, and that they could be captured and destroyed easily when they can be got to congregate together by this means.

An important point to be remembered is that the best work can be done by attacking the rice bug when in the field and before the rice comes into ear, and not by waiting till it has evaded the fields. The cultivator should therefore look out for the insect and its eggs and destroy them. For, if let alone, each pair will in a month or so produce aobut 24 bugs and in two months 288, and so on. The enemies of the bug should also be recognized and must never be destroyed.

[1] Tuba sugar or coarse tuba sirup made from the coconut sap.

The leaf folder is apparently only injurious while in the larva stage. It folds the sides of the leaf together, fastening them with a sticky secretion. Within this protection it feeds, but the principal damage seems to be in distorting and preventing the growth of the plant. (Pl. IX, fig. 1.) While very commonly found on the west side of the island, it did its greatest damage to the fields located near Inarajan on the east side of the island, which were at least two months later than the fields on the west side. From specimens furnished the Bureau of Entomology, United States Department of Agriculture, the insect was not identified further than the family Pyralidæ and the subfamily Nymphulinæ. No methods of control can be offered at this time other than careful hand picking. This might be practical if the work could be performed at timely intervals by cheap labor or by the children of the family.

The stem borer works its way into the base of the stems near the ground or at the first joint. It bores upward, often eating one side of the stem especially near the joints. Evidently it can not turn back inside the stem. The eating of one side of the stem causes the stalks to break and fall over, giving the appearance of badly lodged grain. (Pl. IX, fig. 2.) This insect was common on the newly broken ground but was not found very frequently on the old ground. It was determined as belonging to the same family as the leaf folder mentioned above, and, as in case of the folder, no further determination has been made. Methods of treatment are not known, but from observations of last year's crop, it seems possible to keep the pest under control somewhat by stopping irrigation for a period of time. How effective this measure would be can not be told, but it seems worth trying if a field is being seriously damaged by the stem borer.

GREEN MANURE AND COVER CROPS.

These crops have become very valuable on the station because of their effectiveness in holding weeds in check, especially when the ground is so wet that it can not be cultivated, and their ability to add nitrogen and organic matter to the soil, both of which are lacking in most Guam soils. During the year legumes were used in some combination with nearly all of the other crops. The Whippoorwill cowpea was planted in most instances in place of the Blackeye which was generally used last year. It gave much better satisfaction in regard to yield of both grain and forage.

Green manures.—Velvet beans, cowpeas, mung beans, and soy beans have been successfully turned under with the small one-handled plow which is commonly used with a single carabao, but it was sometimes necessary to use the disk harrow to thoroughly cut up the vines before plowing. (Pl. X, fig. 1.) In one case where

a very heavy growth of velvet beans was present, it was necessary to use a machete to cut the vines before a disk harrow could be used. Corn, vegetables, and other crops have been grown on this ground, but results showing the comparative value of these different green manure crops have not been secured.

Cover crops.—Due to the tropical climate it is possible to grow these crops the year round. From results of different tests it would appear that time of planting in respect to season may be an important factor in determining the variety or kind of cover crop to plant. Some legumes are more adapted to the dry season than others, while from observation it has been found that insects are more injurious during certain seasons than in others. From this it would appear that variety and time of planting tests should be run in conjunction, so that a great number of tests will be necessary before definite conclusions can be drawn.

In all the tests made during the year, velvet beans have been the most effective in preventing erosion, keeping down weeds, and lasting for long periods of time. (Pl. X, fig. 2.) However, in some tests cowpeas and mung beans have been all that could be desired.

A test of cover crops was conducted in the papaya orchard during the year. Duplicate plats were planted June 21, 1917, of velvet beans, Blackeye cowpeas, mung beans, jack beans, and pigeon peas. The mung beans were severely attacked by a leaf hopper but later recovered. The other crops were only attacked to a slight extent. The cowpeas and velvet beans were infested with a leaf miner (a tineid, family Gracilariidæ) which works under the epidermis. The cowpeas and mung beans matured on August 15 and September 1, respectively, but they made such a small growth and were so short-lived that they were unsatisfactory as a cover crop for a permanent orchard. By November 1, the velvet beans were making an excellent cover crop. The jack beans were not so effective as the velvet beans, but more so than the pigeon peas. Conclusions drawn from this test are that the velvet bean was the best cover crop in spite of having to be cut back to prevent its climbing over the papaya trees, while the jack bean was second. Pigeon peas make a poor cover crop until they become large, and then they crowd other plants and rob them of moisture in dry periods. Cowpeas and mung beans mature in too short a period and do not cover the ground sufficiently.

The cover crops in the citrus orchard, consisting of velvet beans, jack beans, and cowpeas, were found to be effective in the order named, although in the second planting where the Whippoorwill was planted instead of the Blackeye, cowpeas were making a very good showing at the end of the year. The velvet beans kept down weed growth better than either of the others. On October 4, the jack beans and velvet beans were fenced and a comparative pasture

experiment was started with pigs, results of which are reported with the animal husbandry work.

In a planting of velvet beans made last November on corn ground, half the area was staked and the other half left for the vines to run on the ground. The first picking of mature pods was made on June 3 and yielded on the staked plat 21.6 bushels of seed per acre, and on the unstaked plat 9.54 bushels per acre, or not quite one-half as much as the plat where the vines were raised from the ground. At the close of the year the second picking was nearly ready and from all appearances it will fully bear out the above results. From these results and from observation it would appear advisable to stake the ground for seed production.

A large quantity of velvet bean seed has been distributed during the year. A number of farmers have been induced to try the velvet bean as a cover crop among coconut trees.

Numerous tests of various kinds are being carried on with leguminous cover crops, and their uses are being taught to native farmers with the idea of getting these valuable crops started on the island. While velvet beans have made the best cover crops on the old land, cowpeas and mung beans have done better on the newly broken ground, besides furnishing a supply of edible beans, an important item from the standpoint of the native farmers.

A shelling percentage record was kept on a number of cover crops when harvested, with the following average results: Cowpeas 69.2 per cent, mung beans 54.7 per cent, velvet beans 56.25 per cent, soy beans 60 per cent, jack beans 54.8 per cent, pigeon peas 62.5 per cent, and string pole beans (garden variety) 66.2 per cent.

TOBACCO.

This project has been continued along the same lines as in previous years, i. e., a study of the effect of shade, fertilizers, and insect enemies of tobacco. Most of the work has been concluded and permits of certain conclusions being drawn. As has been previously reported,[1] these tests were made on plats 12 by 100 feet and run in duplicate or triplicate. In reporting the results, averages of all the plats are given.

Effect of shade.—Shade for the tobacco has consisted of coconut leaves laid on bamboo frames. (Pl. XI, fig. 1.) This furnished only a partial shade, probably about one-half, as the leaflets are about the same width as the open spaces. Shading tobacco has reduced the yields, as shown in the tables below. The average yield from the shaded plats for the three years was 41.29 per cent, while the plats not shaded made an average yield of 58.71 per cent. For 1917

[1] Guam Sta. Rpt. 1916, p. 15.

FIG. 1.—RICE AT INARAJAN SHOWING TWISTED AND DISTORTED GROWTH DUE TO LEAF FOLDER.

FIG. 2.—RICE ON NEW GROUND ATTACKED BY STEM BORER WHICH CAUSES BREAKING OVER OF THE PLANTS.

FIG. 1.—HEAVY GROWTH OF COWPEAS CUT WITH DISK HARROW AND PLOWED UNDER WITH SMALL ONE-HANDLED PLOW.

FIG. 2.—BANANA FIELD WITH COVER CROP OF VELVET BEANS WHICH SUCCESSFULLY KEPT DOWN WEEDS FOR MORE THAN A YEAR.

and 1918 the mean average from the shaded plats was 262.2 ounces of leaves, and from the check or unshaded plats 333.2 ounces.

Effect of shade, spray, and fertilizers upon yields of tobacco.

Year.	Shaded.	Unshaded.	Sprayed.	Unsprayed.	Fertilized.	Unfertilized.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1916	35.44	64.56	54.01	45.98	57.99	42.00
1917	39.27	60.73	57.24	42.76	46.63	53.37
1918	49.16	50.84	56.62	43.38	62.74	37.26
Average	41.29	58.71	55.96	44.04	55.79	44.21

During 1918 there was little difference in the shaded and unshaded plats, due probably to fewer clear days, as it rained nearly every day, and therefore the shade was not so effective as it might otherwise have been.

Comparative effect of different treatments on yields of tobacco for 1917 and 1918.[1]

Treatment of plats.	Average yield per plat.			Treatment of plats.	Average yield per plat.		
	1917	1918	Mean.		1917	1918	Mean.
	Ounces.	*Ounces.*	*Ounces.*		*Ounces.*	*Ounces.*	*Ounces.*
Check	441	225.5	333.2	Fertilized, sprayed	490.6	541.5	516
Fertilized	410.6	423	416.8	Fertilized, shaded	240	392	316
Sprayed	522.6	276	399.3	Sprayed, shaded	378	374	376
Shaded	338	186.5	262.2	Fertilized, sprayed, shaded	286	438	362

[1] As the stand was uneven, the 1916 figures were based on yields per plant instead of per plat, so they were not used in this table.

Shading improved the quality of the leaves, as shown in the following table. The shaded plats gave an average of 8.92 per cent of first-grade leaves, while the unshaded plats averaged only 3.9 per cent. When the 1916 results are compared with those of 1917 and 1918, a greater difference is noted in the data especially with respect to grade 1. This is most probably due to a difference in variety, as the tobacco used in 1916 was of imported improved varieties, the seed of which did not germinate the next year, so that a native variety was substituted in order to continue the work. It is possible that the imported varieties were less subject to insect attack than are the native varieties. The same standard of grades was used in every case, the leaves produced being divided into four grades, as follows: Grade 1, perfect leaves, or those with no holes in them; grade 2, leaves containing six or fewer holes one-half inch or less in diameter; grade 3, leaves with undamaged outlines but containing holes larger than those of grade 2; and grade 4, all leaves not meeting the requirements of the other grades.

Effect of shading on quality of tobacco leaves.

Year.	Grade 1.		Grade 2.		Grade 3.		Grade 4.	
	Shaded.	Unshaded.	Shaded.	Unshaded.	Shaded.	Unshaded.	Shaded.	Unshaded.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1916	20	8.50	20.80	11.70	15.20	12.50	44	67.30
1917	4.50	1.40	12.13	9.41	9.01	7.49	74.32	81.69
1918	2.26	1.81	10.50	15.02	51.92	37.97	35.31	45.20
Average	8.92	3.90	14.48	12.04	25.39	19.32	51.21	64.73

Effect of fertilizers.—The fertilized plats were given applications of commercial fertilizers at the rate of 320 pounds nitrate of soda, 320 pounds acid phosphate, and 120 pounds potassium sulphate per acre before planting. Fertilizers have been very beneficial (Pl. XI, fig. 1) in every case, except during 1917 when the unfertilized plats gave a higher yield than those receiving an application of fertilizer. No reason can be assigned for this difference, unless, due to the long drought, the fertilizers did not become readily available. The tables above give an average result for the three years of 11.58 per cent more tobacco from the fertilized plats and for 1916 and 1917 a mean average yield of 416.8 ounces from the fertilized plats and 333.2 ounces from the unfertilized, or 83.6 ounces in favor of fertilizing. The effect of fertilizers on the grade of the leaf is given in the table below, this showing that fertilizers did not improve the grade, as the unfertilized plats gave a greater amount of first. second, and third grade, and a smaller number of fourth grade, leaves.

Effect of fertilizers on quality of tobacco leaves.

Year.	Grade 1.		Grade 2.		Grade 3.		Grade 4.	
	Fertilized.	Unfertilized.	Fertilized.	Unfertilized.	Fertilized.	Unfertilized.	Fertilized.	Unfertilized.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1916	12.20	13.57	17.42	17.21	15	15.63	55.38	53.58
1917	2.79	2.50	7.13	11.09	6.39	7.82	83.68	78.58
1918	1.44	3.04	11.49	14.99	45.08	44.40	41.98	37.57
Average	5.48	6.37	12.01	14.43	22.16	22.62	60.35	56.58

Insect enemies.—This work has consisted of a study of the insects injurious to tobacco and means of controlling them. The insects most seriously damaging tobacco have been given in previous reports[1] as a species of gryllid, *Heliothis assulta*, and *H. obsoleta* more commonly known as the false budworm of tobacco, the bollworm of cotton, or the earworm of corn. The latter insects in the larva stage feed on the bud and the leaves, often entirely eating the leaf, leaving only the midrib and a few veins. The native farmer practices hand

picking to some extent, but the fields often present a very ragged appearance.

The application of lead arsenate in both liquid and dry forms has been found at this station to hold the insects in check. In 1916 the treatment consisted of a mixture of 7 parts corn meal and 1 part powdered lead arsenate sprinkled on the plants once each week. In 1917 ashes were substituted for the corn meal but otherwise the treatment was the same as in 1916. In 1918, 4 pounds lead arsenate in paste form and 4 pounds lime were mixed in 100 gallons of water and the mixture applied with a spray pump. The methods were apparently equally effective. Not only has lead arsenate kept the insects under control to a large extent but a previous table (p. 41) shows that the average yield from the sprayed plats was 399.3 ounces, that the unsprayed (check) plats gave only 333.2 ounces, while the plats both fertilized and sprayed but not shaded gave an average yield of 516 ounces per plat.

The effect of the spray on the quality or grade of the leaves is given below.

Effect of sprays on quality of tobacco leaves.

Year.	Grade 1.		Grade 2.		Grade 3.		Grade 4.	
	Sprayed.	Unsprayed.	Sprayed.	Unsprayed.	Sprayed.	Unsprayed.	Sprayed.	Unsprayed.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1916	20.80	9.85	22.95	14.85	17.40	15.50	38.85	59.80
1917	2.96	2.20	9.74	9.38	7.43	9.18	79.86	79.24
1918	3.31	.37	20.01	3.38	54.73	31.91	21.94	64.34
Average	9.02	4.14	17.57	9.20	26.52	18.86	46.88	67.79

This shows that the spray considerably increased the first, second, and third grades of tobacco leaves, giving a larger amount of marketable leaf. Frequent rains during 1918 reduced the effect of the lead arsenate by washing it off, making it necessary to spray as often as twice a week during part of the season.

Summary.—The work of the three years justifies the drawing of the following conclusions in regard to the growing of tobacco:

1. Shading tobacco with coconut leaves has not been beneficial, but has reduced yields, although it has increased the number of first-class leaves to some extent during the long dry periods.

2. Commercial fertilizers have increased the total yields of tobacco 11.58 per cent, but have not increased the percentage of marketable leaf.

3. Injurious insects can be held in check to a marked extent by the use of lead arsenate.

[1] Guam Sta. Rpts. 1911, p. 29; 1916, p. 15; 1917, p. 22.

4. The spraying with lead arsenate gave a larger yield of tobacco and increased the marketable qualities of the leaf.

5. The use of spray and fertilizers on the same plats resulted in the highest yield and quality of tobacco leaves.

6. The imported improved varieties made a better showing the first year than did the native variety the last two years. The variety work should be continued to see if a more suitable variety can be found for Guam.

SOILS.

On account of the peculiarities exhibited at times by a number of soils and the conditions resulting from plantings recently made on the newly-broken grassland, it has been deemed best to make some general preliminary studies of certain soils, especially those found at the station. This work has already presented some interesting features, especially along physical and physiological lines. The lack of laboratory facilities and of a chemist on the station staff has made it necessary to depend on the Bureau of Soils, United States Department of Agriculture, for all analytical work. About 40 samples have been submitted for mechanical and chemical analyses, a large number of which have been completed. Samples, record of location, and history of each kind of soil are being kept on file so that all material will be available as the work progresses.

The investigations this year have principally been directed toward a study of the newly-broken grasslands in comparison with the older and more productive soils. In view of the fact that greater production of foods has made necessary the cultivation of new areas, this has been of some importance. The extreme dwarfing and dying of plants and whole crops (Pl. XI, fig. 2, and Pl. XII) often for several successive plantings on the newly-broken grassland have given rise to a serious problem. During the year several crops were tried to determine if one or more of them could overcome this adverse condition. The crops grown on the land were mung beans, cowpeas, Darso, Schrock kafir, Sudan grass, rice, velvet beans, soy beans, roselle, pineapples, corn, tobacco, 7 additional varieties of grain sorghum, 2 varieties of sweet sorghum, 3 varieties of cotton, and vegetables of all kinds. Only the first 6 crops gave a satisfactory growth after repeated plantings. All of these did well on the older station ground, which is apparently very similar to the new ground.

A paraffined pot experiment was carried out to determine the manurial requirements of these soils. Commercial fertilizers and several materials from local sources were used, but the results were not definite enough to be conclusive. Pots given complete fertilizer of nitrogen, potassium, and phosphorus produced higher yields than other pots. Such fertilization was also beneficial in field tests.

FIG. 1.—TOBACCO PLATS; FERTILIZED ON RIGHT, UNFERTILIZED ON LEFT, SHADED IN BACKGROUND. SHADE FURNISHED BY COCONUT PALM LEAVES ON BAMBOO FRAME.

FIG. 2.—SECOND PLANTING OF GRAIN SORGHUMS ON NEWLY PLOWED GRASSLAND. WHOLE STAND GOOD AT FIRST; DARSO AND SCHROCK IN BACKGROUND STILL MAKING FAIR GROWTH.

FIG. 1.—DWARFED GRAIN SORGHUMS HEADING OUT ON GRASSLAND FALLOWED FOR 6 MONTHS.

FIG. 2.—GRAIN SORGHUMS ON GRASSLAND AFTER 10 MONTHS OF UNSUCCESSFUL PLANTINGS. DWARF HEGARI ON LEFT, SCHROCK ON RIGHT, COWPEAS BETWEEN THE ROWS.

Analyses show that there is not enough difference in the chemical composition to make any difference in productivity of these soils; in fact, the difference is not much greater than would be found in duplicate samples of the same soil. The table below gives a comparison of eight soils, all except two (Nos. 27 and 28, surface and subsurface, respectively) located on the station. Mechanical analyses show the surface soil to be clay underlaid with a clay loam. Sample No. 38 is a composite of the soil taken 8 months after breaking from the newly-broken grassland which had been kept free from weeds and in good condition. All of the first plantings on this soil died and later plantings were greatly dwarfed. Sample No. 39, a composite of the older station soil which has produced good crops for several years, was used as a check in the paraffined pot experiments. Samples Nos. 27 and 28 are from a field that, according to native residents, has been in rice for a period of some 40 years, and is located across the road from the station. Nos. 29 and 30 are from the newly-broken land that had been planted to rice and kept flooded for one month previous to taking the sample. Samples Nos. 31 and 32 were taken from grassland that had been planted to rice years ago but had been allowed to go back to sod or grassland.

From all the data at hand it would appear that the difference in the productivity of the soils is due to a physiological condition, the grass roots apparently excreting a toxic substance that is poisonous or detrimental to other plants, or at least to some others. This work is to be continued and other lines will be taken up from time to time as opportunity offers.

Chemical analyses of experimental soils.[1]

Constituent.	Sample No.							
	38 (old ground).	39 (new ground).	27 (surface).	28 (subsurface).	29 (surface).	30 (subsurface).	31 (surface).	32 (subsurface).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica (SiO_2)	43.68	44.57	44.32	43.86	44.03	44.19	43.22	44.74
Titanium (TiO_2)	.92	.92	.82	.83	.82	.82	.82	.82
Iron (Fe_2O_3)	14.33	13.96	12.80	14.42	13.58	15.61	14.89	18.03
Alumina (Al_2O_3)	21.08	21.50	23.53	23.61	21.41	22.67	22.61	20.94
Manganese (MnO)	.25	.29	.10	.62	.16	.48	.32	.20
Lime (CaO)	1.17	1.22	.81	.82	.87	.72	.72	.75
Magnesia MgO)	2.28	2.20	2.45	2.93	2.44	2.80	2.50	2.75
Potash (K_2O)	.57	.45	.60	.61	.61	.62	.59	.55
Soda (Na_2O)	.29	.25	.35	.34	.31	.32	.35	.33
Phosphoric acid (P_2O_5)	.12	.06	.09	.08	.05	.05	.08	.05
Sulphuric acid (SO_3)	.25	.20	.13	.09	.15	.09	.11	.09
Nitrogen (N)	.34	.29	.33	.19	.42	.37	.34	.23
Loss on ignition	14.72	14.09	13.41	11.74	15.16	11.49	13.05	10.94

[1] Reported by the Bureau of Soils, U. S. Department of Agriculture.

HORTICULTURE.

INTRODUCTION.

Much of the horticultural work has been of a pioneer nature during the year, as considerable time has been devoted to nursery work

and the establishment of permanent orchards. The experiments have been fairly satisfactory in most instances. Some records have been lost due to the theft of certain fruits and vegetables.

During the last quarter of the fiscal year Joaquin Guerrero was away from the station studying plant propagation in the Philippine Islands and at the Hawaii Agricultural Experiment Station. Mr. Guerrero has the personal supervision of much of the work in horticulture, which has become more extensive since the addition of the Moritz property.

TROPICAL FRUIT INVESTIGATIONS.

The work accomplished under this project for the first six months was largely of a preparatory nature, much time being devoted to plant house and nursery work. Suitable soil for a nursery is scarce on the station, as it runs together and becomes almost impervious to water. The present location has been well manured, plowed deep, and made as suitable as possible.

Lemons and oranges.—The improvement work with lemons and oranges has not progressed very far. None of the imported lemons and only a few of the oranges have fruited. The oranges seemed to be of a fair quality, but before the crop was ripe enough to be properly judged, all the fruits, including the small ones, were stolen. Several hundred seeds from selected fruit were planted last year and the seedlings have been transferred to the nursery. Work with lemons demonstrated that successful propagation can be made by cuttings. This makes it possible to continue a strain that shows a tendency toward producing superior fruit and thus more rapid progress can be made than by fruit selection and the planting of seeds.

Grapes.—During the rainy season a small grape vineyard was started to determine the ability of grapes to grow on this side of the island. Cuttings of a native grape growing at Inarajan and probably introduced from Spain were made October 22 and transplanted on November 5, having struck roots and put out leaves within the two weeks. An imported variety growing on the station was also included in the test. The native grapes have grown vigorously but the others have made little or no growth.

Aberia gardneri.—A number of plants of *Aberia gardneri* have been transplanted to one of the large chicken runs and have grown very satisfactorily. Severe pruning and a little attention has caused them to fruit, some plants having yielded a heavy crop. The small black fruits make a good jelly or sauce, either of which is very appetizing with meats.

Roselle.—This plant, which is sometimes called Jamaica sorrel or tropical cranberry, has proved to be well adapted to Guam conditions. Thirty plants were placed in one of the chicken runs between

papaya trees on June 21. By January 23, these plants had yielded 126.76 pounds of fruit, which when separated into calices and seed pods weighed 54.71 and 72.05 pounds, respectively. Thus about 43 per cent of the entire fruit is suitable for making sauce, jelly, or wine. The leaves may be used for making jelly and also for "greens," being prepared in a manner similar to spinach. Many people have spoken so highly of the roselle products made from this planting that a larger area has been started so that propagating material can be distributed to all interested parties. Several small packages of seed had been given out and quite a little area has already been planted on the island.

Pineapples.—This crop has been coming into more favor with the people since the Smooth Cayenne slips and suckers given out by the station several years ago have borne fruit. The area devoted to this crop over the island has been largely increased since the better quality and size of the improved over the native variety have been recognized. In order to supply the increased demand for better plants, this station has enlarged its pineapple area, and more suckers for propagation work have been ordered from Hawaii.

Near the close of the year a variety test was started for demonstration purposes. In a small fertilizer test, the plat which received an application of ammonium sulphate contains the largest and most vigorous plants, while the plat to which bone meal was applied is second best. No difference can be noted in the sodium nitrate, acid phosphate, and barnyard manure plats. The check plat is noticeably inferior to all of the others.

Papaya.—The papaya fertilizer and variety test[1] was suddenly terminated by heavy winds on November 22, which uprooted most of the trees. Although the recorded yields are small, as the trees had just come into good bearing and were still loaded with fruit, the results should be comparable and reliable, offering a guidance to further plantings. From observation of the trees, the results would have continued about the same as indicated by the data that were secured before the windstorm.

This test consisted of two varieties or kinds, seed of which were secured from the island of Madagascar and the Hawaiian Islands. The fertilizer used was chicken manure applied once a month to the fertilized rows, each tree receiving the same amount, which when rather wet weighed 6.5 pounds and varied to 3 pounds when dry. The trees were transplanted 8 feet apart each way in the orchard. This was found to have been rather close, as the leaves of the neighboring plants overlapped. It would probably have been better to plant the trees 10 feet apart, placing a plant opposite a space in the next parallel row.

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[1] Guam Sta. Rpt. 1917, p. 37.

Apparently the drainage in the orchard area was not so good as the surface soil indicated. The trees had shed a good many leaves and after the windstorm the roots were found to have decayed very badly, although new roots were well started at the time the plants were uprooted. In all probability the trees would have recovered had it not been for the heavy wind.

The rows were not all the same length, but the experimental data are based on the number of trees. A detailed summary of the data in regard to each row is given below:

Summary of papaya data.

Row No.	Treatment.	Spaces left by dying trees.	Number of male trees.	Number of female trees.	Number of fruits picked.
1	Fertilized	1	7	12	198
2	.....do	2	9	9	157
3	Check	1	10	9	39
4	.....do	2	6	11	4
5	Fertilized	1	3	13	105
6	.....do	2	7	9	61
7	.....do	2	7	8	136
8	Check	1	6	9	46
9	.....do	0	7	9	56
10	Fertilized	0	4	10	47
11	.....do	1	6	5	12
12	Check	0	6	5	16
13	.....do	0	3	5	30
14	Fertilized	0	3	5	34
15	.....do	0	3	4	8
16	Check	0	2	3	14

Rows 5, 6, 7, 8, and 9 were of the Madagascar variety, all others of the Hawaiian variety. The fruits picked were all mature except a few that were counted after the trees had been blown down, and all were of marketable size.

The following table gives the yields of the female trees and a comparison of the two varieties.

Effect of fertilizers on yields of female papaya trees of Madagascar and Hawaiian varieties.

Variety.	Fertilized trees.			Unfertilized trees.		
	Number of trees.	Total number of fruits.	Average number of fruits. per tree.	Number of trees.	Total number of fruits.	Average number of fruits per tree.
Madagasear	30	302	10.06	18	102	6
Hawaiian	45	456	10.13	33	103	3.12
Total	75	758	10.1	51	205	4.01

The total number of fertilized trees yielded 758 fruits, or an average of 10.1 fruits per tree, while the unfertilized ones gave a yield of only 205 fruits, or an average of 4.01 fruits per tree. It was also a

noticeable fact that the fertilized trees had the better quality of fruit. The difference in variety in the unfertilized trees was not only noticeable in regard to yield, that of the Madagascar being nearly twice that of the Hawaiian variety, but also in regard to quality, the fruit of the former variety being better and having also a smaller proportion of seed and seed cavity.

The table below gives the number of female and male plants that were in the orchard, this becoming evident when the trees blossomed. The male trees were nearly all removed on August 21, or about eight months after transplanting, as they produce no fruit and only a comparatively few are necessary for pollination.

Number of female and male trees of Madagascar and Hawaiian varieties of papaya.

Variety.	Total number of trees in orchard.	Female trees.		Male trees.	
		Number.	Percentage.	Number.	Percentage.
Madagascar	78	48	61.53	30	38.46
Hawaiian	127	78	61.41	49	38.58
Total	205	126	61.46	79	38.53

An interesting feature of this experiment was that both the Madagascar and the Hawaiian variety had almost exactly the same percentage of male and female trees. This large proportion of males, nearly two-fifths of the entire orchard, represents lost labor and waste orchard space, in order to avoid which this station has been trying to graft or inarch female scions on papaya stocks. Satisfactory results were obtained by grafting small young shoots taken from the female trees upon young papayas in the plant house. No field tests have been made as yet. The inarching experiments failed. The graft is much easier and is not so complicated but that with a little care the average laborer can do the work. Provided field tests prove as satisfactory as those in the plant house, the possibility of getting an orchard of female trees by this method is assured.

The trees near the windbreak of pigeon peas were little damaged by the heavy winds. These pigeon peas were planted at the same time the papayas were transplanted. The protected trees continued to bear fruit and apparently recovered after shedding their leaves, which was thought to have been due to poor drainage as mentioned above. From this it would seem that pigeon peas planted in rows suitable distances apart and running across the direction of prevailing winds will form efficient windbreaks and prevent damage from rather heavy winds.

Conclusions that can be drawn from the papaya experiments are:

1. Good drainage is essential for the papaya to make its best growth.

2. Yields were more than doubled by applying chicken manure to the orchard.

3. Fertilizers improved the quality of the fruit to a marked extent.

4. The unfertilized Madagascar variety yielded nearly twice as many fruits as the unfertilized Hawaiian variety.

5. The quality of the fruit of the Madagascar variety was superior to the Hawaiian variety and the former also had a smaller seed cavity, thus giving a larger proportion of meat.

6. There was a great loss due to the fact that nearly two-fifths of the trees in the orchard were male and therefore bore no fruit.

7. Grafting small shoots from female trees on small papaya stocks was practical, the work being conducted in the plant house.

8. Windbreaks prevented damage from ordinarily heavy winds.

The above test is being repeated and in addition to the data collected in the first test, records of weight of the fruits are to be secured. At the close of the fiscal year the papayas were in blossom and some fruits were already of good size. The trees in another papaya test in which barnyard manure is being used in place of the chicken manure have been bearing fruit for sometime but the test will not be completed for several months.

Cooperation.—Cooperative work in the preparation and use of some of the fruits grown in Guam has been carried on by this station and Mrs. Glen Briggs. Native and introduced fruits have been used only to a limited extent by most of the people of the island, due chiefly to lack of knowledge relative to proper methods of preparation. A large number of new and practical methods of preparing and serving these fruits have been devised. This work has created a new interest in local fruits, especially among the natives. The station receives for filing copies of recipes and articles on ways or means of using these fruits.

Introductions.—During the year the following fruit and nut trees were introduced: Mangosteen, lanzón (*Lansium domesticum*), and mango (seed) from the Bureau of Agriculture, Manila, P. I.; *Amygdalus persica nectarina*, *Annona purpurea*, *Byrsonima crassifolia*, *Coccoloba diversifolia*, and *Macadamia ternifolia*, from the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry, United States Department of Agriculture; and pecans from Oklahoma.

GARDEN VEGETABLES.

This project has been continued along the same general lines as in previous years, i. e., with varieties, times of planting, and fertilizers

and their application. Much of the station work has been in progress for a number of years and permits the drawing of conclusions which it is planned to offer in a bulletin to be issued in the near future. The success of special efforts directed toward greater food production has been manifested in the increased amount of vegetables produced throughout the island.

Aside from the vegetable growing work conducted at the experiment station at Piti, the gardens at the naval government farms at Barrigada and Libugan, the latter at an elevation of 600 feet, and those of Jesus Flores at Inarajan, who has been the most successful private vegetable grower on the island, have been of particular value as demonstrations to the local farmers. Plate XIII, figure 1, shows the demonstration farm at Barrigada. This is under the direction of the Department of Industries and has a patrolman (U. S. marine) as foreman. Besides vegetables, there are bananas, lemons, oranges, coffee, papayas, and other fruits on trial. Perhaps the most noticeable progress in the garden work at the experiment station was shown in the growing of tomatoes and in the work with certain sprays.

Tomatoes.—Heretofore it has been believed impossible to grow tomatoes profitably in marketable quantities. However, during the year a great many have been produced in certain districts over the island. During the latter part of the year, 2,000 pounds a week was sent to the market in Agana from Inarajan alone. These were raised from seed distributed from this station. The most satisfactory variety as to yield is one introduced some years ago from the Caroline Islands by Father Cristobal. It is medium sized but very rough. From the first crop grown on the station, three plants were selected to continue the strain. These plants bore fairly smooth fruits which in turn produced a more desirable fruit than that secured from the seed of unselected plants. Improvement work will be continued largely with this variety.

Sprays.—Much trouble has been encountered with fungus diseases on a great many of the vegetables, and to a greater extent on such vine crops as muskmelon, cucumber, squash, and pumpkin. Both the powdery and downy mildews have been found but they are evidently more difficult to control here than in the United States. The disease makes its appearance soon after the plant begins to run and blossom, gradually killing the whole plant. Of several sprays used only sulphur in frequent applications seemed to control the disease. The plants responded very quickly to the treatment and produced excellent fruits. However, the available supply of sulphur was not large enough to carry on an extensive or conclusive test, as will be done during the coming year.

On some soils fruits have failed to set on the vines. This difficulty has been overcome in several instances by an application of lime dusted on the plants and around the roots.

Tobacco in the manufactured form or as small broken leaves scattered over and around the vines has been found to be beneficial for repelling aphids.

SEED AND PLANT DISTRIBUTION.

During the year there has been a steady and increased demand on the station for seeds, caused to a large extent by the encouragement given the planting of more foodstuffs. This demand was anticipated, and to meet it, seed for distribution was produced in much larger quantity than usual on the station and also ordered from the United States. Even this increased supply was insufficient to meet the demand at times. The planting of the staple crops such as corn, beans, and sweet potatoes has been constantly recommended as a means of supplying the most needed foods.

The saving of seeds has been greatly encouraged. Methods of preserving seeds from climatic influences by placing them in glass bottles sealed with coconut oil and in tin boxes with tight lids have been suggested as the best practical means for the farmer to adopt for retaining vitality of seeds and preventing low germination.

During the year there were 8,170 packages of garden seed distributed; 1,728 plants and rooted cuttings; several hundred pounds of legume seed, mostly velvet beans, jack beans, and cowpeas; and a large number of sacks of grass roots. Although the total number of packages of vegetable seed distributed was not particularly large, the packages have been larger than usual, especially in case of beans, the packages of which were from one-half to one pound in weight, making up the bulk of the packages distributed. Plate I shows the agronomy and horticultural exhibit at the 1918 Guam Industrial Fair. This exhibit emphasized the importance of seed selection and showed some of the products grown from such seed. The exhibit attracted most favorable attention and was chiefly of value from an educational standpoint.

COCONUT EXPERIMENTS.

The coconut experiments have been extended during the year. The work now consists of fertilizer tests, use of cover crops, tests of distance of planting, disease and insect investigations, and other experiments of a general nature.

Fertilizers.—The tests at the Cotot stock farm have been progressing as well as could be expected. The trees on the two plats receiving ammonium sulphate and acid phosphate are doing better than any of the others. The plat which has been kept free of weeds

FIG. 1.—GARDEN DEMONTRATION ON NAVAL GOVERNMENT FARM AT BARRIGADA.

FIG. 2.—COCONUT TREES ON SAIPAN ATTACKED BY ASPIDIOTUS DESTRUCTOR OR A. OCEANICA.

and grass has made a good growth, as has the plat receiving lime. Those receiving no fertilizer have not been as vigorous as the others.

The cooperative experiment on the Atkins, Kroll & Co. holdings at the north end of the island consists partly of four fertilizer applications as follows: Plat 1, check; plat 2, ammonium sulphate 150 pounds; plat 3, acid phosphate 200 pounds; and plat 4, ammonium sulphate 75 pounds and acid phosphate 100 pounds. All of these plats are 1 acre in size and consist of 48 four-year-old trees. A guard row of trees was left between and across the ends of the plats to prevent the results being influenced by the treatment of nearby plats.

Cover crops.—Cover crops are being tested on the above mentioned plantation on plats arranged like those for the fertilizers. The crops used are velvet beans, jack beans, and cowpeas. Seeds of the velvet bean and jack bean were distributed during the last half of the year in large quantities to several ranches for trial as a cover crop to keep down weeds in coconut orchards. Urgent station work has prevented a checking up of the results of these distributions.

Distance of planting.—During May, a fire accidently started burned off the heavy matted growth of the Para grass in the experimental plats at Cotot and completely destroyed all the trees in the distance of planting test.

Disease and insect pest investigations.—As was reported last year, considerable interest has been aroused in Guam relative to coconut diseases and insect enemies. Reports had reached this office of a serious coconut pest present in neighboring islands and rumors were numerous of outbreaks of a similar nature on this island. C. W. Edwards, animal husbandman in charge of the station, visited the island of Saipan and found a scale insect doing considerable damage. Practically every coconut tree on the island was found to be badly infested. Approximately 10 per cent of the trees had already succumbed to the pest and in general production had ceased (Pl. XIII, fig. 2). The fruit and foliage of bananas, papayas, and breadfruit trees were also found to be infested, though in these cases the ill effects were not apparent to any great extent. The scales were so closely packed that they overlapped each other, entirely hiding the leaves and other parts to which they were attached. They are nearly transparent, flat, circular, thin, and papery, varying in color from pale yellow to nearly white, with a pale yellow spot in the center, forming a flaky crust over the entire under surface of the leaf, and being found on young and old trees alike. Specimens were immediately submitted to the Bureau of Entomology, United States Department of Agriculture, for further identification and information. A local Japanese official informed Mr. Edwards that the

scale had been identified as *Aspidiotus oceanica*. The presence of the insects on the under side of the leaf only and certain other characteristics would seem to be more indicative of *A. destructor*. The outbreaks of disease reported in Guam have been investigated and found to be of an entirely different nature and not likely to be dangerous. Many of the symptoms have indicated root disease, but no discoloration of the wood, such as would indisputably prove its presence, has been found. What is apparently "little leaf" or "dwarfing" has been found, but only in cases where unfavorable physical conditions surround the tree. Bud rot has been reported a number of times, but in each case investigation has failed to disclose any symptoms of this disease. A leaf disease which has evidently passed unnoticed was found to be present, being identified as *Pestalozzia* sp., probably *P. palmarum*, by the Bureau of Plant Industry, United States Department of Agriculture. It is not considered so alarming as it was at first thought to be, but should conditions become favorable for its growth it might become a serious disease, as it seems to be prevalent to a certain extent all over the island.

No specific coconut diseases other than the leaf disease (Pestalozzia) were found by Dr. W. H. Weston, jr., a pathologist of the United States Department of Agriculture, during his short stay in Guam.

In connection with the coconut disease studies, it has been noted for some time that apparently adverse conditions are present in certain locations which cause the gradual dying of trees. The principal symptoms of this trouble are dwarfing of the leaves, abnormal tapering of the trunks near the top, falling of the immature and distorted nuts, and the general unhealthy appearance of the tree. It is thought that this is caused by unfavorable soil conditions or physiological effects.[1]

Clean cultivation.—On the Atkins-Kroll plantation at Tarague, an opportunity was offered during the year to observe the difference between clean cultivation and no cultivation. Originally this plantation was virgin forest. After clearing away the trees, a heavy growth of underbrush and second growth trees sprang up very quickly and soon covered the ground. Among the trees and brush 3,000 coconuts

[1] After the typhoon of July 6, 1918, a great many coconut trees were examined after having been broken off or blown down and uprooted. It was noticeable that in nearly every case where trees tapered near the top they did not break off, but were uprooted. The roots were not nearly so numerous nor so extensive as the roots of the vigorous or normal trees that did not taper. They presented an unhealthy appearance, as if many of them had been broken off or had rotted some time previously. If it had not been for the smaller number of roots, it would have appeared that they had been broken by a heavy wind at some former time, making it impossible for the tree to receive proper nourishment. Under these circumstances the tree would probably gradually grow smaller, tapering at the top where it makes its growth and finally dying. On the other hand, the small number of roots might indicate unfavorable soil conditions or a physiological effect that at present can not be determined.

were put out in 1910 by a Japanese planter who has been on the same plantation since that time, being now supervisor of the whole plantation. Of this number 100 trees have been kept clear of brush and other plant growth during the eight years. The others were given no cultivation until they were 6 years old. In May, 1918, the difference between the plat in which the undergrowth had been kept down and the remainder of the plantation was very apparent, both as to size of trees and as to number of nuts per tree. For comparison the nuts were counted on an average block of 40 trees each in the clean and adjoining uncultivated area, the areas containing approximately 1 acre each, and aside from the difference due to cultivation the soil and other conditions of these two plats were similar in every particular. The table below gives a comparison of the two, showing that the clean cultivated area gave an average of 15.95 more nuts per tree, or 90.6 per cent more nuts per acre.

Comparison of clean cultivation and no cultivation of coconuts.

Treatment.	Number of nuts on 40 trees, or 1 acre.	Average number of nuts per tree.
Clean cultivation	1,342	33.55
No cultivation	704	17.60
Gain in favor of clean cultivation	638	15.95

The coconuts on the cultivated land were also larger and of better quality than were those on the uncleared section. According to the statement of the Japanese planter, the trees that had been kept clean began to flower when 4 years old and bore nuts when 5 years old, while those that had not been given clean cultivation flowered when 6 years old and produced nuts when 7 years old, making a difference of 2 years in the time of bearing.

COCONUT AND COPRA SURVEY.

Coconuts constitute about the only money crop of the island, and copra, the dried kernel of the coconut, is the only export of any size. As coconut trees grow on a type of soil, such as sandy beach land, which in a great many instances would not grow other crops profitably, they form the basis of an important industry that under present conditions can be supplied by no other crop.

This station is often asked for information regarding certain practices relative to the making of copra. There are no available experimental data of a local source upon which to base conclusions. In the absence of such information this station has made a coconut survey among the principal growers or planters, using a printed question-

naire and making personal visits to each grower. By this means considerable data have been secured, the average of which should be fairly reliable and will form a working basis until more accurate data become available as the experimental work progresses.

The following paragraphs give some of the most important data that were secured by the survey:

Number of nuts required to make 100 pounds of dry copra.—This was found to vary according to the size of the nuts, being reported by the various planters from 220 to 300 field-run nuts. The average from all records was 265.8 nuts.

Number of nuts borne by each tree a year.—The estimate in this case was a guess by a great many of the farmers and ranged from 30 to 300, according to the variety. It was noticed that the estimates of the larger and more careful planters were lower than those of the ordinary grower. It was found that the estimate in many of the latter cases did not agree with the actual number as shown by an analysis of the other data given. Such estimates were corrected accordingly and the resulting average was 72.75 nuts per tree each year. The manager of one of the largest companies on the island, who has kept records, says:

> Data are not at present complete on this subject. However, we have established the fact that trees on a plantation in Guam, properly planted and the ground well cleaned, bear up to as high as 100 and more mature nuts per annum. The average on such plantations may be placed, at the highest, as 75 mature nuts per annum. The average of the whole island will not, in our opinion, run more than 35 or 40 nuts per tree per annum, i. e., nuts maturing each year. We believe that actually an average of 35 nuts is fairly high.

Another reliable company even puts the average as low as 30 nuts per tree.

Bearing age of trees.—This was almost invariably answered as five to eight or more years, according to location and the cultivation given. Along the seashore and on good land given cultivation the trees were said to bear in 5 years, and where the conditions were unfavorable often not before 10 years. Trees, according to further of these records, do not bear vigorously until 10 or 12 years old and reach their maximum at 15 years.

Yield.—This was found to be much more uniform than was thought to be the case before the survey was made. The lowest yield from an acre of trees per year given in the records was 498 pounds of dry copra and the highest yield was 1,600 pounds. The average from all plantations included in the survey was 1,000.8 pounds of copra.

Number of days required to sun-dry copra.—The general practice among coconut planters of the island is to dry the copra upon mats placed in the sun. Most growers considered three good sunny days sufficient to dry copra for market, while those growers who were also

buyers and shippers considered that four to five sunny days were required to properly dry the product. The average of all records was 3.29 days. It has been the practice among many of the farmers to rush the copra to market soon after making, so as to lose as little weight as possible by shrinkage. This method of handling should be discouraged, as the green copra has a tendency to mold and become rancid thus lowering the grade.

Shrinkage in drying copra.—The loss in weight from the time of making copra until it is sold to the local buyers was found to vary from 14 to 40 per cent, with an average of 24.56 per cent for all records. Under favorable conditions the shrinkage is from 30 to 35 per cent when the copra is landed at Japanese or United States ports, and may be as high as 45 per cent under adverse conditions.

Percentage of coconut oil.—Very few of the planters could give this percentage, but the prevailing opinions, based upon much practical experience, was that from 10 medium-sized nuts one bottle (about 1/5 gallon) of oil could be expressed by native methods. The native process is to grate the meat of the nuts, mix with a small quantity of water, and then squeeze the milk out by hand. This diluted juice or milk is then boiled and the oil skimmed off as it rises to the top.

In one analysis of Guam sun-dried copra an ether extract of 68.14 per cent was obtained. The average given by four persons reporting in percentages was 70.9 per cent. These estimates were for the oil content secured by modern methods of extraction.

Kinds of nuts making the best copra.—Nearly every planter agreed that well-matured ripe nuts that had fallen to the ground make the best grade of copra. These nuts absorb all, or nearly all, of the water in the cavity of the coconut. However, most growers do not wait for the nuts to fall but pick them, notches being cut in the trunk of the tree to assist in climbing. Picking the nuts before they fall is said to be practiced because of the need of ready cash. The copra yield is generally considered to be increased by piling the nuts in a dry place for a month before splitting.

Kind of nuts on the island.—There are a number of types varying in methods of fruiting, size of bunches or fruiting stalks, and color, size, and shape of nuts. In general the growers only recognized a few kinds. These are named either from the source of the first seed or from some characteristic of the nut. The most common kinds given in the records are: (1) Guam, jalla, jaya, or native coconut; (2) latpugua or larpugua, a small coconut growing in large bunches; (3) Manila or Philippine coconut, introduced from the Philippine Islands, and considered one of the best copra nuts, the trees yielding a large number of nuts of fair size with thick meat; (4) Caroline coconut from the group of islands by that name, the nut being long

with thin husk; and (5) canuon, a variety with a sweet edible husk when the nut is young.

Methods of growing seedlings.—The planters were almost equally divided in opinion between the advisability of placing the nuts in a nursery and of planting them directly in the field, although the first plan was given a slight preference. In planting in the nursery a partially shaded spot, usually under a tree and protected from the wind, is selected. The ground should be well prepared and kept moist. The nuts are laid on their sides on the surface of the soil or are partially buried, and the trees are transplanted after reaching two or more feet in height. In planting directly in the field, the nuts are planted in place and left to germinate. Some of the planters object to this method because it is said that the rats destroy many of the nuts, necessitating replanting, and also because in the nursery method the ground of the orchard site can be used for other crops during the germination of the nuts in the nursery.

Best distance to plant.—Many of the planters had considerable experience with different distances of planting, varying from 20 to 40 or more feet. The average distance found to be the best by all the planters from whom records were secured was 30.7 feet. This makes approximately 46 trees to the acre or 115 to the hectare. However, the average for the whole island is much higher than this, as the early planters favored closer spacing and this has resulted in lower yields, as the more progressive of these planters found to be the case in later years.

Cost of producing copra.—As it was impossible to find the cost of establishing a bearing plantation of long years' standing, data were secured only on the actual cost of making the copra on the ranch, including picking and splitting the nuts and removing and drying the kernel. This varied according to the help and the experience of the copra makers. The average cost from all records was found to be $0.674 per 100 pounds. It is the general practice among the smaller growers for the whole family to take part in the work and in this way keep down expenses. In making copra the nuts are not husked but are cut in two by a couple of blows with a machete and the kernel removed with a peculiarly constructed knife.

BANANAS.

In the banana fertilizer experiment at Barrigada, which is being carried on in cooperation with the naval government of Guam, the trees were bearing fruit at the close of the year. Weights are kept of the bunches from the different plats. Jack beans and velvet beans were planted between the rows as cover crops. The velvet beans proved to be the better crop (Pl. X, fig. 2) and were planted on the whole experiment after the jack beans matured. Pigeon peas have

been planted at intervals to serve as windbreaks, for which purpose they have been most efficient for the ordinarily heavy winds that have occurred during the last two years.

As was mentioned last year this planting is of the Lacatan variety. Among the American population of the island there is a much greater demand for these bananas than for those of other local varieties. They have readily sold at 3 cents a pound by the bunch, when the other varieties were bringing not over 1 cent a pound.

During the month of August, 11 varieties of bananas were planted on the station's experimental plats. These were largely secured from local ranches, as the station's plantation was not extensive. These plants will be further propagated and used in a variety test with other imported varieties as these are secured. Cowpeas were used as a cover crop for these bananas with satisfactory results.

COFFEE.

A coffee test to determine the efficiency of barnyard manure as a fertilizer and bananas as a shade was started during the year. The coffee plants have made very slow growth while the bananas have grown rapildy. Some variety work has been begun with seedlings, but the plants are still in the nursery.

At present the island government employs one of the insular patrol force (U. S. marines) on extension work among the coffe growers. The local government is also offering encouragement to coffee planters by providing a market in the Navy commissary for the locally produced coffee. Under this stimulus several farmers have been induced to make new plantings or to increase their former areas.

METEOROLOGICAL OBSERVATIONS, 1918.

By P. Nelson, *Assistant.*

During the fiscal years 1912, 1913, and 1914 records of maximum and minimum temperatures were kept. These have been the only meteorological data available at this station. In order that more complete data relative to the climatic conditions would be available, arrangements for cooperative observations were made with the Weather Bureau of the United States Department of Agriculture during the fiscal year 1917, and a complete outfit of instruments was received from the instrument division and installed during the latter part of the last fiscal year. The taking of observations was begun on July 1, 1917, with the exception of the anemometer, which was not complete upon arrival. The necessary anemometer cups were not received until October 28, 1917, from which date records of wind velocity were taken.

The instruments received and used are as follows:

1 Standard cistern barometer.
1 Dry-bulb thermometer.
1 Wet-bulb thermometer.
1 Maximum thermometer.
1 Minimum thermometer.
1 Friez anemometer.
1 Friez single register.
1 Wind vane.
1 Standard rain gauge.

The barometer was located on the west veranda of the office building, while the remainder of the instruments were installed in an exposed location on the lawn to the southeast of the office building. The thermometers were placed in the standard Weather Bureau instrument shelter and the anemometer and wind vane were mounted on a pole about 30 feet high, constructed at the station from 2-inch galvanized iron pipe.

One observation was taken daily at 4.30 p. m. local time of the one hundred and forty-fourth meridian, which corresponds to 1.20 a. m., seventy-fifth meridian time.

The year was marked in that it did not have a definite wet and dry season. It will be noticed that an abundant amount of rainfall was recorded throughout the year. Generally the greater amount of rainfall is recorded from July to December, while the period from December to June is comparatively dry. During this year there was 65.6 inches recorded in 144 days in the so-called "wet season" and 35.62 inches in 113 days during the "dry season." No month had less than $2\frac{1}{2}$ per cent of the total for the year; 4 months had 5 per cent or less, 5 months had 5 to 10 per cent, while 3 months had 11.5, 14.9, and 20.6 per cent, respectively. There were not less than 15 days with rainfall in any month, and the greatest number of days with rainfall recorded was 29. The maximum rainfall for 24 hours amounted to 4.47 inches which was recorded on February 19, 1918.

This year was also peculiar in that no severe winds were encountered. As a rule during the period from July to December, or in the "wet season," stormy weather due to typhoons or hurricanes in the vicinity of the island is encountered. These strong winds are generally disastrous to growing crops. The prevailing direction of the wind during the period from December to June was from east to northeast, with a southerly or westerly direction from July to December. During this fiscal year the prevailing direction has been east for 43 per cent of the total, with northeast, southeast, south, north, southwest, west, and northwest next in order. In July the tendency was to the southeast, veering to south during August, with variable winds in September. From October to June, with the exception of the month of March, the prevailing direction was east.

The daily mean velocity for the year was 161.3 miles, and the hourly mean 6.72 miles. The maximum daily velocity of 351.5 miles occurred on February 14, 1918.

The mean temperature of the year was 80.88° F., which does not vary much from observations of previous years. January proved coolest, with a mean of 79.49°, and May warmest, with 82.27°. The absolute maximum for the year, 97.5°, was recorded on July 9, 1917, and the absolute minimum, 68°, on January 3, 1918. A temperature of 90° or over was observed on 80 days during the year.

There were no important atmospheric disturbances recorded during the year. The barometer was fairly steady throughout the period. The average of the monthly means was 29.766 inches, and in no month did the monthly mean go much above or below the average. The mean maximum for the year was 29.779 inches and the mean minimum 29.743 inches, with a range of 0.036 inch. The absolute maximum of 30.09 inches was recorded October 11 and 12, 1917, and the absolute minimum of 29.661 on June 30, 1918, with an absolute range of 0.429 inch. The maximum monthly range was 0.19 inch during August and the minimum range 0.087 inch during February.

The accompanying table summarizes the results of observations taken during the year, the detailed data being on file at the station:

Condensed meteorological data for the fiscal year 1918.

Month.	Temperature.					Relative humidity (monthly mean).	Total precipitation.	Number of days.[1]				Wind.	
	Maximum.	Minimum.	Mean maximum.	Mean minimum.	Monthly mean.			Clear.	Partly cloudy.	Cloudy.	With precipitation (trace to 1 inch or more).	Prevailing direction.	Average hourly velocity.
1917.	°F.	°F.	°F.	°F.	°F.	P. ct.	Inches.						Miles.
July	97.5	72.0	89.40	73.60	81.50	83.40	8.95	1	10	16	23	SE.	.....
Aug	93.0	71.0	88.20	74.00	81.09	88.00	15.13	5	12	13	29	S.	.....
Sept	92.5	71.0	88.34	73.11	80.71	87.50	20.94	6	13	11	26	.....	.....
Oct	91.5	72.0	87.91	73.66	80.79	86.50	11.71	14	9	7	27	E.	6.76
Nov	90.0	69.0	87.51	74.43	80.99	81.30	6.29	17	8	5	21	E.	6.77
Dec	90.0	68.5	87.05	73.83	80.44	81.80	2.58	17	11	3	18	E.	7.22
1918.													
Jan	89.0	68.0	86.03	72.95	79.49	80.40	7.62	18	8	5	21	E.	6.54
Feb	90.0	68.5	86.87	73.67	80.27	83.80	8.53	19	7	2	16	E.	7.21
Mar	91.0	69.5	87.14	73.17	80.16	77.67	2.67	20	8	3	17	NE.	7.64
Apr	96.5	70.0	88.90	73.03	80.96	77.80	3.65	17	8	5	20	E.	6.39
May	91.0	71.0	89.29	75.25	82.27	77.61	5.10	19	9	3	15	E.	7.50
June	93.0	73.0	89.24	74.60	81.92	83.72	8.05	16	6	7	24	SE.	5.80

[1] No observations were taken on 4 days in July and 1 day each in August, October, and June.